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ABSTRACT

Seminars devoted to different aspects of the immediate implementation of cost effective information systems were conducted. A keynote address emphasizing the need for tough management decisions to accompany information systems in the years ahead preceded the workshop reports. The first workshop discussed the impact of new technologies--structured programing, top down design and top down programing--and the management of programing projects. Planning for computer facilities and the budgeting and pricing of those services were the foci of two other groups. One workshop explored the present and potential impacts of minicomputers on the development of cost effective information systems in colleges and universities. Another taught the APL programing language to participants for use in administrative functions. The value of file management systems for simplified database updating, retrieval and report generation was emphasized in the database management seminar. A last group used a system model to develop strategies for academic library management in a time of rapid change. (KB)

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PREFACE

Recognizing the extreme financial pressures facing many colleges and universities in 1976, the EDUCOM Spring 1976 Conference focused on implementing cost-effective information systems now. In order to tackle some of the tough decisions facing management in our institutions of higher education, we must take advantage of available computing technology. However, we must at the same time demand a strict accounting of the costs and benefits of using that technology from management.

Departing from previous conference themes, the Spring 1976 EDUCOM Conference focused almost entirely on management use of computing with an emphasis on evaluation of costs and benefits of the application of computing in management information systems. Format of the Conference was also different. Conferees explored nine topics in depth by participating in a set of sequential sessions of seminars devoted to separate aspects of the general topic. This Proceedings is based on reports from the seminars as well as the keynote address.

Credit for the new theme and format goes to James C. Emery, EDUCOM Vice President and Executive Director of the Planning Council on Computing in Education and Research, who served as Conference Chairman. On behalf of all of the more than 200 conference participants, I thank Jim for the fine conference plan and excellent set of seminars.

Joe B. Wyatt
President, EDUCOM

INTRODUCTION

"Information alone is not sufficient to the needs of higher education systems and campuses in the years that lie ahead. The need is for tough decisions, for decisions that will preserve the essential requirements of higher education in service to American society." So challenges John Millett in the keynote address that opens this volume. This theme is developed not only in Dr. Millett's address, but also in the chapters that follow. Each of the nine workshops reports covers this basic theme in relation to a particular area of application of information systems.

In chapter two, Professor Wesley Graham, University of Waterloo, explores several examples of systems development using a top-down structured programming approach. The workshop also considered how this approach might be used to control and direct a wide variety of systems development projects.

All universities are facing problems of how best to provide computing services for academic, research, and administrative users. Universities have taken different approaches, ranging from dependence upon minicomputers with a high degree of decentralization to a thoroughly centralized approach. Both extremes — and a variety of middle alternatives — are reasonable choices in certain circumstances, The one approach that cannot be justified is to make a choice by default. In chapter three, Robert Scott, Harvard University, summarizes the discussion in the workshop on planning with and for computing in the university.

The use of minicomputers in colleges and universities is growing at an astounding rate. The continuing technological advances of minicomputers present fantastic opportunities to higher education, but also add a number of very serious hazards. The proliferation of minicomputers already has led to substantial duplication of software development, much of which is largely obscured from management. Many other serious issues must also be considered in order to exploit this very attractive technology. No college or university can be oblivious to the problems and opportunities presented by minicomputers. Participants in the workshop on minicomputers, led by Jack McCredie, Carnegie-Mellon University, explored such issues as control of their acquisition, hidden costs of software development and operation, the power and limitations of minicomputers, and the role of minicomputers in a distributed system. These issues are summarized in chapter four.

Another vital area in an overall program of dealing with computing in a university is pricing and budgeting of computing services. Some universities treat computing as a free good (in the manner of an academic library), while others charge for all computing services on a full-cost basis. In this period of tight budgets, institutions have been reviewing their pricing structures as a means of controlling costs and motivating greater efficiency. In a network environment, the way institutions budget for and allocate computing resources becomes crucial, because market mechanisms provide the primary means of governing access to network resources. Chapter five covers a number of these issues: objectives of pricing policies, cost versus price, cost accounting methods, alternative pricing schemes, alternative budgeting schemes, management control considerations, and measurement of results achieved. Workshop leader Carl Palmer, U.S. General Accounting Office, contributed this paper.

A growing number of universities are beginning to use computer-based management aids to assist in administrative decision making. Once university officers look at the consequences of alternative decisions and try to predict the likely results of those alternatives, they very often must use the computer to provide information or perhaps play a more direct role in the decision process. In chapter six, Jon Strauss, University of Pennsylvania, summarizes the significant issues in the use of planning models in higher education. Most examples are drawn from University of Pennsylvania experience, but the principles of using planning models are applicable to a variety of schools.

The role of APL in the overall computing scene has been controversial for a number of years, often clouded by the missionary zeal of APL proponents. The evidence is very strong, however, that for many types of applications, APL offers the possibility of tremendously improved programmer productivity. APL's powerful features can be especially valuable in the development and enhancement of computer-based decision aids. In chapter seven, Allen Rose, Scientific Time Sharing, Inc., reviews the advanatages and disadvantages of APL as a general computational language, and refers the reader to examples of its application to administrative systems.

As universities begin to develop integrated information systems that are imbedded in the overall activities of the institution, the ability to deal with databases — to retrieve data elements easily and flexibly — becomes crucially important. Although administrators within an institution can gain enormous benefits in time and money from dealing with a common database, many pitfalls lie open to the unwary. There are some very important organizational implications of moving to a common database system. In addition, the time necessary to implement a database management system (or DBMS) is most difficult to predict. In chapter eight, Rob Gerritsen and Michael Zisman, University of Pennsylvania, Wharton School, summarize issues covered in the workshop on database management.

It is important for university administrators with an interest in information technology to be aware of both the services and the needs of the library. University libraries are now facing extreme financial difficulties as the cost of publications increases at a much more rapid rate than inflation. At the same time, there are some exciting things going on in library automation. Because these new developments will have both a financial and an organizational impact on colleges and universities, all of us must become aware of the alternatives available for management of academic library services. In chapter nine, Duane Webster and Jeffrey Gardner, Office of University Library Management Studies, Association of Research Libraries, cover the issues discussed in the workshop on library management, and present a case study format for evaluating management alternatives.

Computer based management information systems have the reputation of being extremely costly and frustrating to use, especially in a college or university setting. It is a reputation which is often richly deserved. It is clear, however, that cost-effective systems can be developed. One very important part of the process of developing cost-effective management information systems is estimating the value of benefits received because of the availability of new or more timely information. This estimate of benefits can then be weighed against the cost of obtaining the information.

In chapter ten, Frank Land, London School of Economics, reviews one process of estimating these benefits that was discussed in the workshop on Economic Analysis of Information Systems.

Throughout the Spring Conference, and therefore throughout this volume, emphasis has been placed on practical and effective means for the college or university administrator to evaluate and use computer-based information systems. Cost-effective resources for information management are available now. It is up to us to take advantage of these powerful management tools.

James C. Emery
Conference Chairman

CHAPTER 1

by JOHN D. MILLETT

Tough Decisions in the New Depression Of Higher Education

Keynote Address

1.0 INTRODUCTION

I have a very simple thesis I wish to expound at the opening of this 1976 EDUCOM Spring Conference. That thesis is just this: information alone is not sufficient to the needs of higher education systems and campuses in the years that lie ahead. The need is for tough decisions, for decisions that will preserve the essential requirements of higher education in service to American society.

By the statement of this thesis I do not intend to suggest for one moment that higher education systems or campuses can dispense with information. On the contrary, I shall argue that our information requirements are more exacting than ever before in our history. What I wish to say is that information – no matter how precise, how comprehensive, or how timely – cannot and will not substitute for management, leadership, and governance in higher education.

There is, of course, no purpose in beating a dead horse. I had thought by this time there were no persons left so naive as to think that computers could make decisions. But every so often I still encounter some individuals who appear to believe that if only the college or university had more information about itself, its future course of action would be clear. No doubt more information is desirable. And the computer has indeed immensely enlarged our capacity to process data in large quantities, to analyze trends, and to suggest future expectations within specified parameters. But the computer processes available information. It does not make decisions. Only leaders and representative assemblies can make decisions.

2.0 THE NEW DEPRESSION IN HIGHER EDUCATION

I do not have time to embark here upon an adequate discussion of the "new depression" in higher education. I can only assert that we in our colleges and universities are experiencing a major depression. My own belief is that this major depression is with us for as many years ahead as any of us care to think about, or to plan for. There are many explanations for our economic doldrums, and almost all of them have some kernel of truth. Most explanations in my judgment fall short of the reality.

It seems to me that there are two basic reasons for the new depression in higher education. One basic reason is public confusion about just what it is that we do produce in our colleges and universities. And the second basic reason is some public doubts about the social utility and hence the economic value of our products, provided of course that we know what those products are. If there is uncertainty about what we produce, and if there is uncertainty about the economic value of our products, why then should we be surprised by the circumstance of economic depression?

I emphasize public confusion and public doubt because higher education is a public enterprise. Of the total income of all institutions of higher education other than income for auxiliary enterprises, 60 percent comes from governmental appropriations, 25 percent from charges to students, 9 percent from philanthropy, and 6 percent from miscellaneous sources. Higher education is not supported by its direct consumers, the students. About 70 percent of all operating income is derived from governments for different kinds of institutions: public and independent, research universities and general baccalaureate colleges. The essential fact remains: public funding based upon public attitudes and perceptions determines the economic well being of higher education.

What do our colleges and universities produce? The products have been variously described by various persons, but essentially there is a basic agreement. The products are educated talent, the preservation of knowledge, the advancement of knowledge, and the demonstration of the use of knowledge. To this listing may be added the certification of talent based upon ability rather than some other criterion, and the criticism of social institutions and behavior in the interest of their self-renewal. Assuming we accept some such identification and enumeration of our outputs, we in higher education are accustomed to recognize how general in qualitative terms and how imprecise in quantitative terms these products are.

A single example must suffice here. All of us accept the proposition that educated talent is a major product of higher education. We measure this output in terms of degrees granted to individual persons in some 30 principal groupings of some 350 different subject matter areas or major concentrations of knowledge. We know what we produce in terms of degrees granted. But what do we know about the quality of all this talent? And what do we know about why we produce it?

This last inquiry raises the second public concern about higher education, a concern about the social utility and economic value of our higher education products. We in higher education are wont to declare that we produce educated talent on the basis of individual ability and motivation. We declare our purpose to be the development of an individual's cognitive and related skills to the fullest extent of the individual's competence. Such an avowal of objective satisfies certain complexities of access, of process, and of output. But this formulation of our role ignores completely the economics of higher education; it provides no standard of value for our output and no criterion for its cost.

The truth of the matter is that higher education desires a state of economic affluence without wanting, or understanding, any of the constraints of economics. Because so much of our financial support comes from public planning – that is, from governmental allocation of resources – we in higher education expect governments to accept our own estimate of our economic worth. In a society where economic resources are scarce, where competition for governmental assistance is strong, and where political process determines who gets how much, our own estimate of our own worth is not likely to be convincing.

I can do no more here than express the conclusions I reach about the past and prospective economic circumstances of higher education. I state those conclusions for your own consideration. Higher education did enjoy a substantial advancement in its economic circumstances between 1950 and 1970, and especially between 1958 and 1968, because a considerable economic value was given by the market place and by government to the production of educated talent and to the production of knowledge. Higher education enjoys a reduced economic circumstance today and for the foreseeable future simply because a lesser economic value is given by the market place and by government to the production of educated talent and to the production of knowledge. And I may add as a footnote that in my judgment faculty collective bargaining cannot in any way alter our economic circumstances; collective bargaining may satisfy faculty frustration about changing economic circumstances but it will surely not alter those circumstances.

I mention economic depression for higher education because economics will in large part determine the future of colleges and universities. All of our decision-making must be made in the context of economic circumstances that for the remainder of this century will be very different from the recent years, those "golden" years of 1945 to 1973. Our information processing and analysis will need to illuminate these changing circumstances.

3.0 PROBLEMS OF RETRENCHMENT

As I think about the next twenty-five years and as I examine the problems of expenditure retrenchment for various colleges and universities, I see three especially troublesome problems that higher education not only must confront but also must resolve. I want to say something about these problems because they are critical. I also want to say something about these problems because they call for substantial change in the future behavior of higher education. This change will not be easy to bring about. I see no hope for encouraging such change except by extensive analysis and sharing of information.

3.1 Duality of Purpose

The first problem I want to mention is a confusion about the purpose of higher education in relation to the instruction of students. In the past decade or so higher education has found itself caught in a duality of purpose that was not of our own devising. The traditional role of higher education has been to educate and certify talent on the basis of individual competence and performance. But in the circumstances of the 1950's and 1960's higher education found itself also cast in the role of a social welfare agency asked to assist young people to upgrade their intellectual competence and motivation and so to achieve an upward bound socio-economic status in our society.

Two factors I believe joined in the decade of the 1960's to bring about some confusion about the role of higher education. One factor was the growing concern with the continued presence of poverty in our society, and a gnawing suspicion that poverty was related to deep-seated forms of racial discrimination in our nation. The other factor was the remarkable change occurring in the structure of the American labor market between 1950 and 1970 that did open up new opportunities for the employment of educated talent. The two factors combined to encourage the expectation that higher education could be an avenue of social mobility and of improved economic status for large numbers of persons. In the process of promoting individual betterment it was appropriate that the opportunity for improvement should be offered widely, including an outreach to racial and ethnic minorities that had endured various kinds of discrimination in the past. And to this outreach must be added the increased participation of women in the labor market, and their increased demand to be freed from discrimination based upon sex.

If quantitative data were available about the class structure of American society, I believe this information would indicate a considerable increase in the size of the middle class between 1945 and 1970, and perhaps as much as a 50 percent decline in the size of the poverty class. We do know that employment in agriculture declined by nearly 60 percent, that employment in professional and technical jobs increased 180 percent, that employment in service occupations increased 75 percent. Altogether, while non-agricultural employment was increasing by about 60 percent, employment in so-called white-collar jobs was increasing by 86 percent. As Daniel Bell has described the change, the United States in the third-quarter of the Twentieth Century moved from an industrial society to a post-industrial society.

Higher education played a major part in this economic and social transformation. The principal contribution of higher education was the production of educated talent. Another contribution was the production of knowledge upon which the technology of atomic energy, space exploration, health care, communications, and other economic activity was largely built. Higher education appeared to be closely related to economic growth and to social betterment. As a consequence, higher education became identified with social welfare.

Unfortunately, this identification was almost completely based upon three circumstances: technological advancement, economic growth, and a changing labor market. Then suddenly our society began to understand that technological advancement could also mean degradation of the environment, that economic growth was based upon consumption of energy supplies and raw materials which were exhaustible and subject to higher price levels, and that the labor market demand for educated talent could change from a circumstance of shortage to a circumstance of surplus. Higher education as a social institution had little to offer in the amelioration of environmental pollution, in the adjustment of economic growth to decreased consumption of energy and raw materials, and in the elimination of a surplus of educated talent on the labor market.

Colleges and universities now find the economic value of their product reduced. As enterprises colleges and universities must now make do with lesser economic resources. Society no longer has need of the same levels of productive output by higher education. Perhaps it may be more accurate to say that student enrollment remains high, but that the public disposition to support current levels of cost has declined.

If income declines, colleges and universities must either reduce their costs or increase their charges to students. Both kinds of action are happening. Costs can be reduced in one of two ways: by reducing salaries or by reducing output. If output is reduced, then presumably employment will also be reduced. If the output of educated talent is reduced, the role of higher education as an agency of social mobility and of economic betterment for many individuals in our society will appear to be sacrificed. Thus the conflict arises between higher education as a social welfare institution and higher education as a formulator and enforcer of intellectual standards.

There are very few if any persons in higher education or American society who are opposed to quality in the performance of colleges and universities. For the present we may ignore the problems of an operational definition of quality. I am disposed to believe that in the face of substantial complexities, our colleges and universities did in general maintain commendable standards of performance in their instruction of students. The certification of degree recipients on the basis of qualitative standards remains the first role of higher education.

In the process of retrenchment, there is a very real danger that the process may be seen as a conspiracy to reinforce old patterns of racial and ethnic discrimination. I believe this danger can be avoided, but it will take careful and determined action to prevent the appearance and the reality of discrimination. Here is one of the tough decisions to be made by higher education in the years ahead.

I wish I had a ready answer to the question about how information can illuminate, indeed guide, future decision-making about access to higher education. Let us assume that access will be restricted because of reduced labor market demand for educated talent and because of reduced public and other resources provided for the operation of our colleges and universities. The tough decision to be made will be how to structure the reduction of access. It will not be sufficient to base access solely upon test scores. It will be necessary to base access upon qualitative standards that also permit some appropriate racial, ethnic, and sexual balance. This objective can be realized currently by decisions based upon rank in class for high school graduates. This kind of standard has some utility so long as many high schools tend to have a concentration of graduates according to race or ethnic background. If and when high schools no longer exhibit some concentration of students by race or ethnic characteristics, then other means for achieving some balance in access must be sought. There can be no avoiding the tough decision to ensure that enrollment reduction based upon qualitative standards must not also bring about discrimination based upon race, national origin, and sex.

3.2 Lack of Income/Expenditure Analysis

There is a second kind of tough decision confronting colleges and universities in the years ahead. Faculty members, professional staffs, and operating staffs tended generally to participate in the economic gains of higher education in the years from 1950 to 1970. Today, many of these groups set their goal as one of preserving those gains against the ravages of inflation. We seldom ask what factors brought about the inflation in the first place, nor do we evidence much interest in preventing future price inflation. We appear to be concerned solely about protection of our income status, and even with some improvement in that status. The costs of higher education have substantially increased under the pressure for economic betterment of college and university staffs. The tough decision is whether or not these costs shall be maintained.

If public support of higher education tends to diminish, and if enrollment should decline in the face of reduced labor market demand for educated talent, then colleges and universities are compelled to re-examine both their patterns of expenditure and their pattern of income. Thus far, I would contend that our colleges and universities have not done an adequate job of analyzing these patterns. There are exceptions, to be sure, but the job of analysis is a continuing one requiring both sophistication of detail and simplicity of summary.

In my own judgment these two needs can be met without any great difficulty if only the determination to do so is present within a college or university. I have my own version of an appropriately simple format for analysis of expenditures in a matrix that shows output programs, support programs, and auxiliary enterprises as the stubs and particular objects of expenditure as the headings. But my purpose here is not to advocate any particular analytical framework for the expenditure analysis of a college or university. Instead, I want only to emphasize the essentiality of some process of analysis, coupled with careful consideration of the factual findings.

It is common knowledge that the college or university enterprise is labor intensive. If we omit the cost of auxiliary enterprises and such specialized activities as teaching hospitals and independent operations, on the average we find that the compensation costs for personal services will require about two-thirds of an operating budget. The remaining one-third will be spent for supplies, equipment, services, and transfer payments. The costs of higher education are predominantly the costs of salaries and fringe benefits for the people who work within the college or university.

As I have observed earlier, colleges and universities must have more income or they must reduce costs within the constraints of the income they are able to obtain. And I have already mentioned that if costs are to be reduced, these economies will have to be found first in the costs of compensation for personal services. As I have studied the governance of college and university campuses in the past four years, I have found one major consequence of increased faculty and student participation in budget decision-making. I have found more and more evidence of internal conflict between the costs of faculty salaries and of student aid on the one hand and the possibility of increased income through higher charges to students on the other hand.

Needless to say, faculty representatives either in a college or university council or in a collective bargaining unit are not going to propose a reduction in faculty salaries. The general objective today is to play catch-up in faculty salaries, to achieve increases equal to the cost of inflation. Yet one possibility for increased income for a college or university, public or private, lies in tuition charges to students. Obviously, student representatives are not likely to approve proposals for larger tuitions. Thus a direct conflict emerges within the academic community: increased salaries versus increased tuition.

At this point a further factor emerges. Increased tuition can of course be offset by increased financial assistance to students. Indeed, the whole thrust of federal government interest in providing financial assistance to students beginning in 1944 has provided a continuing incentive to colleges and universities to raise their tuition charges. If a college or university is financially to benefit from federal government aid to students, that benefit can only be realized from increased tuition charges to students. In recent years, moreover, state governments have begun substantial student aid programs, often as an offset to rising tuition charges in public colleges and universities.

There are two complications in this whole area of student financial assistance as an offset to increased tuition charges. One complication is that student financial assistance tends to be available to students from families below the median family income in our economy. It is possible that tuition charges in public and private colleges and universities have in some instances begun to approach the point where they serve as a positive obstacle to enrollment for students from families above the median in family income. The other complication is that student financial assistance available from governmental sources may not meet actual student financial need. Both public and private colleges and universities in recent years have found themselves spending as much as a half billion dollars a year in student financial aid from general income.

Thus the cost of student financial aid becomes a factor in the expenditure analysis of a college or university. Both faculty and student representatives are reluctant to advocate any reduction in expenditures for student aid, while at the same time realizing that the cost of student aid has become a major item of expense for their college or university. Student attitudes tend to favor the admission and enrollment of fellow students from a variety of socio-economic backgrounds. Faculty members tend to favor the admission and enrollment of students of good academic promise, and they see student financial aid as an essential ingredient of the desired recruitment policy. The two groups tend to oppose any reduction in student financial aid expenditures, while realizing that the cost of such financial aid is a priority competing with faculty salaries and is an inducement to still higher student tuition charges.

I would add one other concern in this review of the tough choices of expenditure analysis. For nearly twenty years I have been a strong advocate of a closer integration between the analysis of college and university income and the analysis of college and university expenditures. The recommended accounting and financial reporting practices for colleges and universities have made some progress in this direction in recent years, although not nearly enough in my own judgment. We now classify income from various primary sources as unrestricted and restricted, although there are considerable differences in the definitions we give to these two categories. And the standard categories of income sources now recognize sales and services of at least three different kinds of operations, plus income from independent operations.

Recently, I have set forth in a published paper a format or framework of analysis for integrating expenditure and income data within colleges and universities. The ideas presented there are by no means new, and certainly not original with me. Yet I continue to be surprised that so little use has been made of this particular analytical procedure.

The essence of the framework is a kind of market-analysis of each cost center among the output departments of a college or university. For each such cost center there must be both a cost of outputs produced and a statement of income generated from instruction and other activities. I urge this kind of analysis because as costs continue to rise I think departments and other production centers of a college or university must be equally concerned with the income they produce.

I emphasize this kind of income-expense analysis because I am convinced that colleges and universities must generate new services if we are to maintain viable operations in the future. It is fairly clear that instruction of students may well be a declining activity producing less income in the next twenty-five years than it produced in the past twenty-five years. It is fairly clear that research is going to be much less of a growth activity in the next twenty-five years than it was in the past twenty-five years. I see the prospect, however, of a considerable expansion in public services produced on a charge basis, including particularly adult general education. The problem is how to motivate a change in faculty behavior that will encourage efforts to produce new services and to generate new income. It seems to me that one of the major challenges in information analysis today is the challenge of helping to motivate change.

Obviously then administrators in colleges and universities confront tough decisions about college and university costs, priorities, and income. The framework of information analysis must identify these tough decisions, help to clarify the issues involved, contribute to their community-wide discussion, and assist the decision-making process. This prescription is asking a great deal of our information systems, but we dare not ask less.

3.3 Inadequate Delivery Structure for Higher Education

In the third place, I want to say a few words about the delivery structure for higher education services. We hear a great deal today about the costs and deficiencies in the structure of health care delivery in the United States. And we have reason to be concerned about health care delivery. As an interested layman, I have the impression that in the United States we are sadly deficient in our analysis of health care delivery and in our capacity to devise improved structures of health care delivery. But we in higher education need to be equally concerned, indeed even more concerned, about the delivery structure for our own services as well.

Public systems of higher education have come in for a good deal of criticism in recent years on the ground that they overbuilt their facilities during the 1960's. Personally, I believe this hindsight does an injustice to the achievements of public higher education in the decade of the 1960's. As a public system administrator during those years I am well aware of our major concern, and our principal objective. That concern and that objective were to ensure a place somewhere in the system for every student who presented himself or herself for enrollment. And in general that objective was realized. This accomplishment was no mean achievement.

To be sure, circumstances have changed, as I have been trying to point out throughout this presentation. Enrollments in some public colleges and universities have declined, although enrollment pressures do continue in some places and in some programs. Some public campuses built or expanded in the 1960's and even as late as 1970 to 1972 never developed the enrollment size originally projected for them. Now that public support may decline, either in terms of dollars of constant purchasing power or in terms of actual current dollar amounts, and as enrollments are reduced, we may have uneconomical units on hand for the delivery of higher education service.

As of 1972 I identified 2,945 separate college and university campuses in the United States. I have been wanting to bring these data up to date as of the autumn of 1975, but the higher education directory for this current year is as yet unavailable. I am sure that the present number of campuses, in spite of some closures and mergers in the years 1972 to 1975, will be over 3,000. Included in this total of 2,945 campuses were 210 doctoral-granting universities, 241 comprehensive colleges and universities, 883 general baccalaureate colleges, 1,183 two-year colleges, and 513 specialized professional schools.

The problem in the delivery structure of American higher education is that of economical and viable size. The average size of public doctoral-granting universities in 1972 was nearly 18,000 students; the average size of private doctoral-granting universities was just above 8,000 students. The average size of comprehensive public colleges and universities was 8,100 students; the average size of private comprehensive colleges and universities was 5,600 students. The average size of a public general baccalaureate college was 2,000 students and for a private baccalaureate college was 1,100 students. The average size of private junior colleges and for private specialized professional schools was 500 students.

As you are aware, there is a good deal of argument about the minimum and the maximum desirable enrollment size for colleges and universities. The Carnegie Commission on Higher Education expressed concern about enrollment size in its 1972 report on the more effective use of resources and again in its final report at the end of 1973. The Commission proposed a minimum size of doctoral granting and comprehensive institutions of 5,000 FTE enrollment, a minimum size of 1,000 enrollment for liberal arts colleges, and a minimum of 2,000 enrollment for community colleges.

I would be inclined to quarrel somewhat with these figures as of 1976. I would argue that 5,000 is a desirable minimum size for any four-year public college, and I believe that a private general baccalaureate college will have great difficulty in survival if its enrollment remains under 2,000 students. The test of economy and viability is two-fold: (1) enrollment sufficient to support three full-time faculty members in every academic department offering upper division majors, and (2) a resource allocation that maintains support costs at under 40 percent of the total educational and general budget.

I am very much concerned, as others are and should be, about the rising costs of support programs at all our colleges and universities. These support programs include academic support, student services, plant operation, institutional support, and mandatory transfers. I do not include here the costs of auxiliary enterprises. These support expenditures have been forced upward by several factors, including rising fuel costs, unionization of operating personnel, and various federal laws affecting employment practices, campus safety, and employee benefits. Another factor has been the need for extensive developmental services to some students enrolled in our colleges and universities.

The Academy for Educational Development two years ago conducted a study of support costs for several independent general baccalaureate colleges and found that support costs amounted on the average to 45 percent of the educational and general expenditures. The colleges in this study ranged in enrollment size from 1000 to 2800 students. We found that in a college of 1000 enrollment support costs were 50 percent of educational and general expenditures, while in the college of 2800 students support costs were 40 percent of educational and general expenditures.

It is not going to be easy to reduce support costs in our colleges or universities, or even to keep them stable. We shall have to eliminate some services and economize on others. Unfortunately, these economies may affect information processing and analysis, as well as institutional planning. With demands for information increasing, we can scarcely expect to reduce our capacity to respond.

I see no solution to the problem of support costs in our colleges, and in some of our universities, except to undertake federation. We simply must become more alert to trends in support costs, and we must find means to reduce these costs on a per student basis. Any such reduction probably means a process of consolidation in the delivery structure of higher education.

Once again, tough decisions will be demanded if the information and analysis of support costs within colleges and universities are to lead to action to hold these costs constant, or even to reduce them. There are all kinds of arguments about why a college should be kept in operation with full independence of its governance, leadership, and management. From experience on both fronts, I am convinced that it is as difficult to close down a college as it is to close down a miliary installation.

4.0 CONCLUSION

There are many individuals, I am sure, who will reject the underlying assumption of these remarks, which is that of a decline in governmental support and some decline in enrollment of the traditional college age cohort. There are many persons who reject retrenchment as a way of life for higher education and who insist that all administrators have to do is to demand more income. Like you, I read the other day about the president of a public university whose faculty voted no confidence in his leadership because in the faculty view he failed to extract the desired level of support from the state appropriation law. Knowing something about the state involved — I am a resident and taxpayer in the state — I can only conclude from this episode that the faculty of that state university is completely out of touch with the taxpayers, the political parties, the governor, and the legislators of that state.

I commend to your reading the 1975 report of the president of the Carnegie Corporation of New York. This report is a sobering statement about the realities of our nation's loss of public confidence in higher education. Mr Pifer wants stronger concern with higher education, and more financial support from our federal government. He is more optimistic than I about the possibility of either.

But regardless of how you or I read the future, I am sure we can agree that governance, leadership, and management within our colleges and universities cannot function except with an adequate information base, and with the analysis of data both in requisite detail and in a useful framework. Maybe the tough decisions I foresee may not be necessary. The information base will be indispensable, in any event. I am inclined to prepare for the worst, and be thankful when the event is better than anticipated. In this day, we can scarcely ask for more.

CHAPTER 2

by J. WESLEY GRAHAM

New Approaches to Project Management Workshop Summary

1.0 INTRODUCTION

During the past three years important new programming and systems design techniques have become the subject of increasing interest. These include structured programming, top-down design and top-down programming.

Primarily, these techniques were introduced to aid the programmer in the development of programs which are easy to debug and maintain. However, the ideas can be more broadly applied to simplify many other aspects of the design, development, implementation and maintenance of computer systems. The objective of the EDUCOM Spring Conference workshop on project management was to examine the impact of such techniques on the management of programming projects.

2.0 BASIC TOOLS OF STRUCTURED PROGRAMMING

The opening session of the workshop presented a review of the fundamentals of structured programming. This permitted all participants to have a basic understanding of the terminology. Programs constructed with the following three rules would be structured programs.

- *Programs are written in modular fashion;* each module has a single entry and a single exit.

- *The two decision elements used are IF-THEN-ELSE and DO-WHILE.*

The IF construction provides a choice of two modules to use, depending on the evaluation of a condition. The important thing about these modules is that they have a single-entry and a single-exit, and both modules exit to a common control point. Thus the complete IF construction has a single entry and a single exit.

The DO-WHILE construction allows the repetition of a particular module zero or more times depending on the evaluation of a condition. When this repetition is terminated, control proceeds sequentially. Thus the complete DO-WHILE construction has a single entry and a single exit.

- *Each program has only one stop instruction,* which is at the end of the mainline routine.

Programs written with the foregoing three rules are linear in nature. Control proceeds from module to module, with no branches to cause logical complexity. Thus the programs should be easier to debug and maintain.

2.1 Structure Diagrams

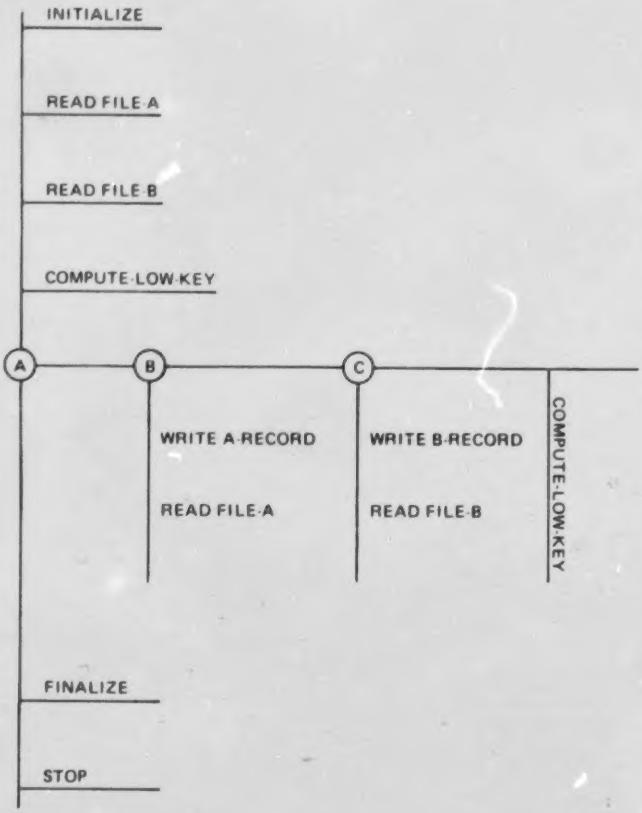
When a program is written in this structured-programming style, the traditional flow chart can be considerably simplified. The diamonds can be replaced by small circles, the rectangles can be replaced by straight lines and all flow-of-control arrows can be omitted. The resulting flow chart is called a structure diagram. Figure 1 illustrates a typical structure diagram. The corresponding flow chart is shown in Figure 2.

2.2 Pseudo Code

Working in a particular language such as COBOL puts many demands on the energy of a programmer. Too much time is spent worrying about the details of the syntax and semantics of the language. At the same time, the limitations of the language cause the programmer to put artificial complexities into a program. To overcome these difficulties, programs can be first written in "pseudo language" which has few rules and can be invented by the programmer as the code is written. When the complete program has been written, the pseudo language can be converted to the language to be used on the computer, such as COBOL or PL/I, and can be debugged. A sample of a pseudo code program is shown in Figure 3.

2.3 Use of Flags

When a special condition arises in a program it is always a temptation to handle it immediately by transferring control to another



A: WHILE RECORDS REMAIN IN ONE OF FILE-A OR FILE-B
B: IF A-KEY = LOW-KEY
C: IF B-KEY = LOW-KEY

FIGURE 1 – A typical structure diagram.

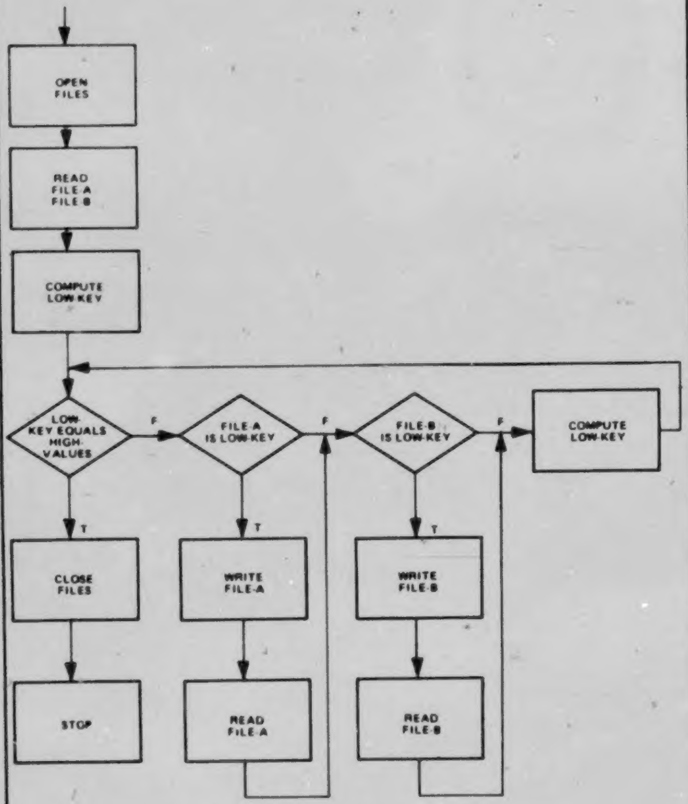


FIGURE 2 – A corresponding typical flowchart.

```
BEGIN MAINLINE
INITIALIZE
INVOKE READ-FILE-A
INVOKE READ-FILE-B
INVOKE COMPUTE-LOW-KEY
DOWHILE LOW-KEY NOT HIGH-VALUES
   IF A-KEY = LOW-KEY THEN
      MOVE A-RECORD TO MERGE-RECORD
      WRITE MERGE-RECORD ONTO MERGE-FILE
      INVOKE READ-FILE-A
   ENDIF
   IF B-KEY = LOW-KEY THEN
      MOVE B-RECORD TO MERGE-RECORD
      WRITE MERGE-RECORD ONTO MERGE-FILE
      INVOKE READ-FILE-B
   ENDIF
   INVOKE COMPUTE-LOW-KEY
ENDDO
FINALIZE
STOP
END MAINLINE

BEST READ-FILE-A
READ FILE-A RECORD INTO STORAGE
   AT END SET A-KEY TO HIGH-VALUES
END READ-FILE-A


BEGIN READ-FILE-B
READ FILE-B RECORD INTO STORAGE
   AT END SET B-KEY TO HIGH-VALUES
END READ-FILE-B


BEGIN COMPUTE-LOW-KEY
IF A-KEY LESS THAN B-KEY THEN
   LOW-KEY = A-KEY
ELSE
   LOW-KEY = B-KEY
ENDIF
END COMPUTE-LOW-KEY
```

FIGURE 3 – Sample of pseudo code.

module. However, such action would cause the current module to have two exits, and would violate the rules as outlined previously. Usually the action should not be taken immediately in any case. To overcome this difficulty *flags* can be used to indicate that the condition occurred. These flags are then tested later in the program and the required action is taken at the appropriate point.

A common example of the use of a flag occurs whenever a file being read comes to "end-of-file". It is seldom that anything should be done at that point. In fact, by setting a flag and proceeding normally, the logic of the program usually becomes quite simple. This use of a flag is shown in the pseudo program in Figure 3. In this case, the flag is the key field in the input area of the record being read. If no record is read because of end-of-file, this key is set to infinity.

2.4 Merging Sequential Files

The example of a two-way merge of sequential files illustrates each of the techniques mentioned in the foregoing paragraphs. Figure 4 is the data-flow diagram, Figure 3 is the pseudo program, and Figure 1 is the structure diagram for this example. This system accepts as input two sequential files, namely FILE-A and FILE-B. Each of these files has its records in ascending sequence by their key. A new file is written called MERGE-FILE which contains all the records of FILE-A and FILE-B in ascending order by key.

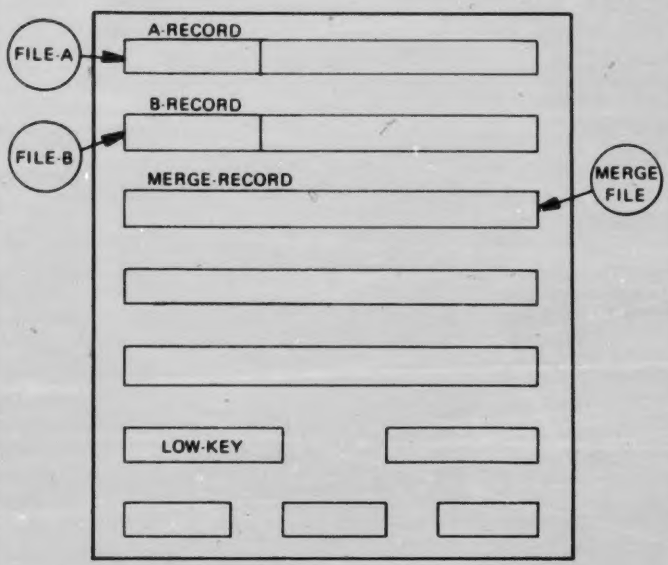


FIGURE 4 – Data-flow diagram of two-way merge.

During the conference, workshop participants were able to modify this merge system in many ways, thus demonstrating that it was easy to maintain, and attesting to the effectiveness of the various tools and techniques.

3.0 TOP-DOWN DESIGN AND PROGRAMMING

The concepts of pseudo code and structured programming lead naturally to the top down design of computer systems. Structured programming permits the entire system to be expressed as a linear sequence of single-entry, single-exit modules. Because each module denotes action, it can be thought of as a "verb". In fact, since the pseudo language is manufactured according to these requirements, these verbs become the verbs of the pseudo language. These verbs are "application oriented" as compared to "system oriented", and thus have a natural meaning to anyone familiar with the application being developed.

As a first step in top-down design a pseudo program using application-oriented verbs can be written to describe the system being designed. These verbs are usually very general in nature at this stage. In the second step, the programmer expresses these general verbs using more specific application-oriented verbs and the same pseudo coding technique. This process is repeated at each level, until the application-oriented modules become quite specific and detailed. Using technique, successive refinement, the system is progressively developed from general high-level components to detailed low-level components. For this reason, it is also referred to as top-down design.

To illustrate the technique, workshop participants developed an accounts receivable system for a credit card company. All facets of the system were developed using pseudo code and structure diagrams, and at each stage of the development a structured walk-through was conducted to detect logical flaws in the system. The participants worked as a team under the direction of a chief programmer (the workshop leader). After the system was designed, it became clear that the actual programs (COBOL was used for implementation) could also be developed or programmed and tested from the top down.

4.0 PROJECT MANAGEMENT

Because top-down design uses a pseudo language with application-oriented verbs, non-programmers can participate in the design of the system. In fact, the end user of the system can confidently take an active role in the design of the system and can monitor its development as closely as is required. This has the following advantages.

- *The problems of communication between the user and the system analyst are minimized.*

- *The user does not have to define all aspects of the project* before it is started. Usually many details of the final project are unknown to the user at the outset, and these can be postponed, and considered when the top-down development has reached a lower level of detail.

- *Much of the mystery of the computer system disappears* from the user's point of view, as he is actively participating in the design process.

When the design has reached a reasonable level of detail, the implementation can begin, once again from the top down. This too has many advantages

- The implementation phase takes place in parallel with much of the design.
- Since the code is written from the top down, high level logic in the system receives a thorough testing.
- The system gradually "come to life" and can be demonstrated in a restricted way at an early stage of implementation. In this way serious misunderstandings can be detected before high levels of expenditure have been reached.
- Since the system begins to operate at an early stage, it is possible, and in fact likely, that the user will begin to use it before the system is completely developed. This helps eliminate the acceptance test so common in an application system's development cycle.
- The entire project takes on a "lively" characteristic which generates enthusiasm in all parties. The user sees results early and is enthusiastic. The system developers are enthusiastic because they see the fruits of their labor at an early stage and have some indication that they are satisfying the user.
- It is easy for all parties to determine whether or not the project is on schedule. If it does fall behind schedule, the system at least partially works, as it is being developed from the top down.

To illustrate these points workshop participants considered the development of a system for terminal access to a data base. Since all participants were associated with education in some way, the hypothetical data base was student records, and the user was considered to be the registrar and the community served by the registrar's office. The system to be designed as an elaborate one, but it became evident that a useful sub-system could be implemented within one month. This system could be progressively developed until it had all the required features.

5.0 CONCLUSION

The techniques of structured programming can be applied to the design of a computer system so that its design and implementation can be carefully monitored by all parties, including the user. Originally, structured programming was developed to simplify the logic of a program so that it could be more easily understood. The same techniques can be applied to the overall design of the system, thus greatly improving the communication between all parties involved in the design process. In turn the technique contributes significantly to the ability to manage a project to a successful conclusion.

CHAPTER 3

by ROBERT H. SCOTT

Planning for Computer Services

1.0 INTRODUCTION

This chapter focuses on identification and discussion of the issues involved in planning for computer services: both planning for computer service facilities and planning for the ways in which these facilities can be effectively utilized within an institution of higher education. The workshop at the EDUCOM Spring Conference covering the topic was divided into four distinct sessions. The first concentrated on strategic planning issues; the second on the intermediate range or tactical planning issues; the third on shorter term operational planning issues; and the fourth on a simulation exercise aimed at elucidating the points made in the discussion and at understanding the interrelationships between the three levels.

2.0 STRATEGIC PLANNING

To consider the issues related to strategic planning for competing one must begin with a discussion of the process of planning. This process can be seen as the definition of objectives, the determination of goals, the establishment of programs and projects, and the setting of budgets. While planning, as here defined, has always been done in colleges and universities, it has been performed in an open, recognized, and conscious fashion. For example, a decision to make no change represents a plan for the indefinite extension of the status quo. Yet, this decision has not often been a conscious one by college administrators, particularly those concerned with planning for computing.

Strategic issues related to planning with and for computing in a college or university include: the role of computing at the institution; the long-term objectives and goals of the institution; the specific plan that exists for the institution's development; the direction of development of information processing technology; the way in which the insitution wishes to determine policy in the information processing area; the rate at which expenditure for computing is to change; the history of computing activities at the institution; and the success and failure in applying and managing computing at other similar institutions. In considering each of these issues, one must assure a good match between the computing services provided by an institution for its instructional, research, public service, and administrative programs and the long-term goals and objectives of the institution. Many problems in information processing systems management occur as a result of a mismatch between objectives of the institution and the computing services provided. Inclarity of goals, lack of understanding, or, more likely, lack of senior management involvement can lead to such a mismatch.

3.0 TACTICAL PLANNING

Intermediate range or tactical computing planning deals with problems to be encountered in the two-to-five-year time frame. Primary issues considered here are: form and method of organization; methods to determine computing needs of the served community and ways to analyze these needs so as to highlight the differences between requirements and aspirations; ways to develop concrete middle-range plans; methods for defining service options; methods for determining criteria for option selection; methods for selecting options; and methods for allocating resources and for cost recovery. While strategic planning must involve the policy leadership of the institution, the development of tactical level plans and objectives becomes the responsibility of the computer facility management in consultation with the served community. In the instructional and research areas, the focus must be a definition of an acceptable computing environment and on the expected rate of its development in the desired direction: reduced unit cost, expanded service sophistication and volume, etc. In the administrative area, development of middle-range plans involves primarily the identification of specific systems development or modification programs that meet specific functional or cost reduction needs of the institution. In many colleges and universities, the most important tactical problems are organization and cost recovery. However, both of these areas, while discussed as intermediate-range problems, also have strategic implications. Organization of computing activities within a single institution must reflect institutional structure and needs. Clearly to achieve harmony with the style of the institution, participation of faculty and the served community in the governance of computing must be appropriate to that style. In the area of cost recovery, many issues, including style, are important. Different cost recovery methods are appropriate for different institutions and for the same institution at different points in its development cycle. For example, what is appropriate for an institution which is new to computing and which does not have a large volume of externally-supported research may be very different from that appropriate to an institution where computing is well established and mature and where a large volume of funded research is conducted.

4.0 OPERATIONAL PLANNING

Operational planning issues involve tasks which require implementation within twelve to twenty-four months. Items of concern include: ways in which the insitution can meet short-term needs; ways in which inputs and outputs can be measured and controlled; ways to assure that the institution operates with a high quality of service and with a "user conscience"; and ways in which information developed at the operational level can be fed back as input to the strategic and tactical planning levels.

A major issue of concern at this level of planning is the development of appropriate standards by which short-term operational goals and service quality can be measured. Standards should be developed to control and measure both internal efficiency and external effectiveness measures as in this way they, in fact, develop a contract for expected performance with the service facility. Internal efficiency measures can be developed from industry standards or from discussions with similar facilities at other institutions. In essence, standards and performance measures should relate closely to goals for they embody the determined measures of success. Another important consideration at the operational planning level is the relationship between short-term and long-term problems. For example, short-term investments are sometimes hard to justify, but they may result in long-term benefits. Likewise, inexpensive, prompt solutions to immediate problems may, in fact, represent only a glossing over of more fundamental issues that should be defined and solved for the long term. An example of the first issue is the investment of substantial staff time in the redesign and rewriting of an old computer applications system in order to reduce by a far greater amount the future cost associated with subsequent modifications to that system. An example of the second issue is the continuous investment of one staff person per year to handle modifications to an applications system when the one-time investment of two staff years would reduce the continuing effort to one-quarter of a staff person per year.

5.0 SIMULATING COMPUTING PLANNING

To identify critical issues in planning for computing in a college or university, a simulation exercise using a hypothetical university system can be helpful. In one such exercise a five campus university system in an urban community is described. This system has a developed computing capacity in administration, and a rapidly growing requirement for computing in the undergraduate teaching program. Numerous technical and interpersonal issues are involved. In the simulation, participants are required to describe a proposed strategy for the college system to plan and select appropriate computer services for its community. While computing is an important issue for the college, many of the evident problems in this simulation represent policy and organizational issues for the college that are general rather than specific to computing.

In most real institutions of higher education, general policy and organizational issues are intertwined with policy issues related to computing services. To develop realistic plans at the strategic, tactical and operational levels for the provision of computing services, administrators must first develop or clarify general institutional goals and objectives. By playing the role of administrators in the simulation, university officers may, more easily, realize the importance of developing general goals and of relating those goals to the process of planning for computing services.

CHAPTER 4

by JOHN W. McCREDIE

Applications of Minicomputers

1.0 INTRODUCTION

The primary purpose of the workshop was to explore present and potential impacts of minicomputers on the development of cost effective information processing systems in colleges and universitites. In the workshop participants examined both the benefits and the problems associated with a number of operational systems, and shared experiences with applications in administration, education, and research. General questions such as "Which is better – a maxi or mini?" were avoided. Instead discussion focussed on an examination of what properties of a particular application, within a particular organizational structure, make it a candidate to be successfully implemented on a minicomputer.

It is impossible in a short summary to reflect the primary feature of a workshop – spirited interchange among colleagues from different organizations having widely divergent backgrounds. However, the following sections outline the major topics and present some of the observations contributed by about twenty five people during six hours of discussions.

2.0 TECHNOLOGICAL CONSIDERATIONS

The design and performance space of computers has many dimensions. To reduce this complexity and to avoid semantic arguments, we defined a minicomputer to be one based upon a central processing unit and memory which costs in the range of one to fifty thousand dollars without peripherals. State of the art systems have word sizes ranging from 8 to 32 bits, standard primary memory configurations of 4 to 16 thousand (1024) words, addition times less than a microsecond, a full range of peripherals, and good software support. The Auerbach report, "An Overview of Minicomputers" (4), contains an excellent taxonomy of the characteristics of minis.

Rapid advances in underlying technologies quickly impact minicomputers in the marketplace. Over the past five to ten years the cost of a mini of approximately equal computing power has fallen at about thirty percent per year. Therefore a system that was once classified as a "maxi" is now a mini. At the small end of the scale are microcomputers that often sell for less than a thousand dollars, have word sizes of 4 to 16 bits, primary memories of .5 to 4 thousand words, and limited software support. We examined the Digital Equipment PDP-11 family of systems to see how a number of early weaknesses of minis (e.g. limited addressing capabilities, too few registers, primitieve input/output capabilities, etc.) have been improved.

Vendors now market upward compatible systems that range over factors of five hundred to one along dimensions such as memory size and cost. The minicomputer industry currently has about sixty vendors who sell more than one and a half billion dollars worth of equipment each year. Dollar volume of 1975 shipments advanced about 24 percent from the year before. As customers expand the scope of their applications, they are buying larger and more sophisticated systems each year. One manufacturer reports that the average value of a newly ordered system has increased by almost a factor of three during the past five years. During this same period the unit cost of subsystem components has fallen rapidly. Current forecasts place the mini market at five billion dollars annual sales by 1980. Technological factors pacing such rapid growth include decreasing memory costs, large scale integration of logic circuits (LSI), advances in communications capabilities, and the accumulation of system software and application packages.

3.0 SUCCESSFUL APPLICATIONS

Participants presented a number of case studies in which minis have been used successfully to create operational systems within colleges and universities. Example application areas include the following.

- *Generalized Data Entry:* These systems are based upon a mini that supports a number of video terminals dedicated to data entry keypunch replacement and enhancement. Such systems often have a local disk and printer, and usually communicate with a larger centralized computer for batch processing of master files. These applications feature extensive video formatting and validity checking in addition to localized control of data. Often the person who enters the information directly to the system via a terminal is the same person who previously transcribed data from a source document to a keypunch form for centralized keypunching.

- *Text Processing:* The application discussed in this area is an experimental word processing system developed at Carnegie-Mellon University during the past year. The system is one of many applications implemented on a large timesharing minicomputer. A number of people now use the system routinely to create, edit, and produce high quality manuscripts and individualized letters. The small text processing department at Carnegie is based upon a cost recovery philosophy and is budgeted as a zero net cost operation for the fiscal year beginning July 1976. Analysts will gather usage data during the coming year and compare costs of using this system with stand-alone microcomputer based word processing systems and non-computer systems.

- *Administrative Areas:* The article by J.D. Hepperton (2) served as the focal point for an examination of administrative applications such as on-line registration, library circulation control, payroll, accounts payable, etc. Many people represented organizations where these applications are currently being processed on a large central facility. Discussion centered on the benefits and problems of converting to a mini based system.

- *Timesharing Educational Systems:* There are a number of standalong minicomputers that support timesharing operating systems. Some are particularly attractive for teaching programming courses and for supporting computer aided instructional materials since they provide excellent response and are inexpensive to operate. Other systems are single user machines that support a variety of interactive languages and communicate with larger systems. Many of these systems are designed for the small school or a department within a larger organization.

- *Research Support:* Support of laboratory activities is perhaps the area in which minis have made the largest impact in universities. On-line control of experiments and real time data collection and analysis both have long histories of successful implementations that have increased the effectiveness of the scientist. More recently, however, researchers have discovered that the same mini used for these purposes can be an effective "number cruncher" when it is not part of an experiment. Programmers can tailor an application to a particular configuration and thereby save substantial funds which would otherwise be spent on central, or external, facilities. Such trends cause obvious concerns for managers of general computation centers.

- *Computer System Research:* Many computer science departments are using minis to create new systems in areas such as graphics support, multiprocessors, networking configurations, operating system and language development. Minis are particularly attractive for many of these experiments because of costs, ease of use, and localized instability during development.

Some of the reasons advanced for the success of these applications include:

- low cost
- high reliability
- flexibility due to local control
- modular time phased purchases
- ability to keep pace with technology
- capability to tune an application to a particular user community
- well defined interfaces to users and other systems
- ease of understanding

In some of these applications the mini was used as a stand-alone computer system dedicated to a small set of tasks, but in others the mini was part of a distributed computing network in which tasks are assigned to the subsystem on which they fit best.

4.0 DISTRIBUTED SYSTEM ARCHITECTURES

In a session devoted to distributed system architecture, participants explored a number of different interfaces among mini, micro, and maxi computers. The article by Canaday et al. (1) is an excellent example of one such design. A potential design for a distributed system to serve a college and university consortium served as the focal point for this discussion. Emphasis was on a plan to have each organization acquire just the right amount of hardware to solve its local problems while sharing parts of a larger system for growth and access to more sophisticated applications. The discussion was an exercise in task oriented system design.

5.0 MANAGEMENT ISSUES

Proliferation of minis within an organization causes many problems of management control. The article by W. Roach (3) highlights many of these issues from the perspective of a supplier of centralized information processing services. Some of the points which surfaced during the workshop are:

- hidden costs (programming, maintenance, space, operating supplies, spares, etc.)
- loss of computing revenues to central site
- multi-vendor interfacing problems
- replication and waste of effort
- procurement approval policies
- government contract biases that often favor purchase of minicomputer hardware rather than central services, and other biases which favor lease rather than purchase
- applications expanding beyond hardware capabilities
- naive purchasers
- loss of organizational control
- difficulty of programming due to limited software
- problems with field engineering and spares

In large central computing sites, hardware costs often amount to only 30 or 40 percent of the expenses of the installation. Sometimes a user is sold a mini based on a simplistic comparison of hardware costs to total service fees for alternative modes of supply. The user must then hire and train skilled professionals and often must face many of the issues which take so much time and effort within larger installations (software maintenance, operations, ordering of supplies, maintenance contracts, security problems, personnel problems, etc.).

6.0 CASE STUDY

The workshop concluded with a study of a problem presented by two participants. They were evaluating a minicomputer to augment computer services that their school purchases over a network from a distant university. Although users in the case study were happy with their networking arrangement, they wished to expand usage. Could a well designed mini system help to satisfy their needs in a cost effective way? The discussion of this problem helped to clarify a number of the issues which were raised in earlier sessions.

References

Participants were asked to read the following articles prior to the workshop:

1. R.H. Canady et. al., "A Back-end Computer for Data Base Management", *Communications of the ACM* 17, 11 (October 1974).
2. J.D. Hopperton, "Registration Can Be Fun . . .", *Technological Horizons in Education,* December 1975, Vol. 2, No. 8.
3. W.R. Roach, "Minicomputer and Microcomputers: . . .", *Computers and People,* July 1975.
4. "Overview of Minicomputers", (Auerbach Inc., Philadelphia, Pa.) 1975.

managers are the key resources in any software development activity. The key entry device and operator are the key resources to data entry.

Organizing the cost accounting, resource usage measurement, and budgeting around these key resources in work function cost centers facilitates the analysis and development of budgets and prices. More importantly, it facilitates making the budget work and the prices realistic. The most important aspect is choosing the primary measure of work done, it must be simple and yet comprehensive enough to measure the output of most of the components of your work center. For instance, the number of lines of code for a programming center (scientific, business, etc.) is a simple, but generally insufficient, comprehensive measurement of the work done.

2.0 ESTABLISHING PRICES FOR YOUR SERVICES

What are your goals in pricing services to end users? Typical goals are: to control demand by enforcing fiscal discipline; shift the responsibility for cost justification to the user who consumes the services; and establish accountability for both the data processing activities and the user of data processing services. *There should always be a direct relationship between cost and price of services.* The priority pricing schemes wherein artificially high prices are set based on demand surplus and artificially low prices are set based on a surplus of supply invariably lead to unstable pricing in an environment that, typically, demands stability for sound planning.

Demand may be controlled by manipulating availability or financing, or by a combination of these factors. If you limit total computing capacity or other key resource, demand will ultimately be controlled by the capacity limit. If you limit the financing dollars to those purchasing data processing services, academic departments, administrative departments, etc. demand will also be ultimately limited. There is no simple answer because the goals of maximizing the utilization of the key resource while achieving full cost recovery are both highly desirable but also antagonistic. The key to reducing the conflict between these goals is to require advanced estimates of data processing requirements and then planning appropriately to meet them. Enforcing discipline to the development of these estimates requires, most often, an advance commitment procedure. Under such procedure, the end user submitting the requirements estimate becomes committed to paying for the cost variance if his estimates are not realistic.

In the academic computing services area, it is not realistic for students to be accounted for, billed, or to be required to make advance estimates of requirements. For most faculty there is little potential for obtaining advance estimates of resource requirements with sufficient accuracy or lead time to make them useful for planning. Focusing the financial responsibility for academic computing services at the right level of responsibility, however, provides a useful way of solving this problem as well as focusing the fiscal control of the cost of these services at the right level of responsibility. What is the right level? The Deans and/or the Vice President for Academic Affairs are generally responsible for the budgets for academic instruction and self-funded research. Any fiscal control of the demands for academic computing services should logically be focused on them as the principal end user and financing source. Dartmouth's model of free services for students are basically focusing the financing and control of demand at the university president level. In most larger schools this is probably too high a level and it well may be too high a level of control for many smaller schools.

To be effective, the pricing and billing of services for academic computing must be exercised in a way that end users of services is supplied with understandable bills, organized and supported by resource usage detail, that they can use to make the budgetary trade-offs between computing and other resource requirements of academic instruction and self-funded research.

3.0 HOW TO DO ALL THIS AND NOT BREAK YOUR BACK!

The key ingredients for successful budgeting and pricing are systematic resource utilization measurement tied to adequate cost accounting records. Make cost accounting work for you in:

- identifying expenses
- accumulating the expense information in useful classifications
- aggregating costs by operational center and meaningful categories
- transferring costs among the cost centers according to the work flow
- job, product and system costing
- providing direct support to billings and useful information to the end user

Underneath the cost accounting you must have balanced and systematic resource utilization measurements. Whatever you measure and record will tend to focus attention on that resource usage (the so-called "attention-directing" phenomena). If you measure too much, that attention will be diffused. If you concentrate on certain limited measures, the unmeasured will slip through your fingers. A great deal of care must be taken to establish a resource measurement system that is balanced, concentrates on a limited number of key resource measures, and provides checks on unmeasured areas of resource usage. The system must be maintained and reviewed for sufficiency periodically. It also should be tied directly into the cost accounting and the billing system.

4.0 ROLE OF PRICING IN A NETWORK ENVIRONMENT

The objectives and alternatives of network pricing are very similar to the ones discussed earlier. They are however, more sensitive and complex in a network environment. The constraints are similar but can become very hardened and limited when dealing with different corporate entities (universities, colleges, etc.). In the EDUCOM networking situation it would also appear that proper pricing is even more critical than in most other environs.

In the report of a task group of ADP management professionals, principles, standards, and guidelines for management control of automatic data processing activities and systems are set forth. A portion of this report is included in this volume as Appendix B.

CHAPTER 6

by JON C. STRAUSS

Use of Planning Models at Penn

1.0 FOREWORD

The workshop on planning models in higher education involved four formal presentations. Each presentation evoked a great deal of discussion, not only on PENN planning and budgeting approaches, but also on related approaches employed at other institutions. This report outlines the formal presentations to the workshop. The resulting discussion was lively and stimulating, but virtually impossible to record. Formal presentations covered yearly budget models, equilibrium models, a tenure planning model, and long term budget planning.

2.0 YEARLY BUDGET MODELS AT PENN*

This part of chapter 6 is concerned with yearly budgeting at PENN, its relation to the organizational structure, and the supporting budget models and information systems. Throughout, emphasis is placed on the proposition that budgeting is the quantitative expression of the fiscal planning supporting other planning processes.

The chapter is divided into four parts: responsibility center organizational structure; university budgets; Penn budgeting process; supporting information systems at Penn.

2.1 Penn Responsibility Center Structure

In 1973 the University of Pennsylvania adopted a responsibility center accounting structure to better relate academic and administrative planning to fiscal planning. The Penn responsibility centers are classified as instructional, resource, and administrative service centers.

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*The material for this section was drawn in large measure from: Strauss, J.C., "Administrative Information Systems for Planning", *Defining the Future*, Proceedings of EDUCOM Spring 1975 Conference.

Instructional centers perform the main academic teaching, research and service missions of the university and are responsible for balancing total income to total expense:

- *Total income* includes direct center income and a share of university general income (subvention).
- *Total expense* includes the actual direct costs and budgeted overhead costs of the center.

The Penn instructional centers are the fourteen schools and colleges.

Resource centers provide academic resources and services in support of the schools. They are income-expense budgeted and the bulk of their income comes from general university income.

Resource centers include:

- Department of Intercollegiate Athletics
- Annenberg Center
- Interdisciplinary Center
- Museum
- Library.

Administrative service centers are primarily expense budgeted based on services necessary for support of the instructional and resource centers. Penn administrative service centers include:

- School and Department Libraries
- Student Services
- Department of Physical Plant
- Auxiliary Enterprises
- Central Administration
- Development

Expenses described in Administrative service center budgets, net of any direct income, are spread to the responsibility and resource centers as overhead costs. To allocate overhead costs the budget office uses algorithms driven by factors such as numbers of students and faculty, size of budgets, amount of space, and so on.

Information systems support the budgeting process at Penn in several ways. They provide data on: current and previous year actual and budgeted fiscal performance; and factors affecting fiscal performance. The university information systems also provide mechanisms for: projecting future fiscal performance and developing strategies for performance control; testing submitted budgets; and controlling organizational behavior to budgets.

Because Penn uses the responsibility center structure, university administrators must deal with several issues, some of which are seldom encountered in other colleges and universities:

- Subvention setting
- Responsibility center fiscal performance
- Bank management
- University fiscal performance
- Sizing of resource and administrative service centers

2.2 University Budgets

General income-expense budgets for Penn are represented by a complete 47 row, 9 column budget matrix. In this matrix, rows represent incomes and expenses while columns represent activity types like Instruction, Organized Activities, and Research both restricted and unrestricted. Most budget analysis concentrates on the responsibility center unrestricted operating budget matrices. A typical example is illustrated in Figure 1.

2.3 Penn Budgeting Process

The Penn budgeting process involves four phases: formulation of guidelines on a university basis; preparation of outline budgets for schools, resource centers, and service centers; preparation and test of line item budgets; and operational control of budgets.

SECOND ROUND BUDGET PROJECTIONS
(A Typical PENN School)

REVENUE			
Total Tuition			10,387
Undergraduate Tuition		5,150	
Regular	4,234		
Special	916		
Graduate Tuition		5,237	
Regular	4,611		
Special	626		
Tuition from Special Programs		——	0
Special Fees			116
Financial Aid Income			0
Investment Income			135
Gift Income – Private			0
Grant and Contract Income			0
Indirect Cost Recoveries			979
Sales and Services			105
Miscellaneous Income			0
TOTAL DIRECT INCOME			11,722
Special State Appropriation			0
From General University			1,473
Bank Transaction			201
TOTAL AVAILABLE			13,396
EXPENSE			
Compensation			6,123
Administration		517	
Academic		4,000	
Clerical		474	
Service		94	
Employee Benefits		1,038	
Current Expense			1,212
Equipment			76
Student Aid			1,708
Undergraduate – Regular		1,040	
Undergraduate – Special		44	
Graduate – Regular		624	
Graduate – Special		0	
TOTAL DIRECT EXPENSE			9,119
INDIRECT COSTS			
Student Services			0
Libraries			438
Operations and Maintenance			1,289
Utilities – Direct		383	
Utilities – Indirect		195	
Non-Utilities – Direct		403	
Non-Utilities – Indirect		308	
Auxiliary Enterprises			0
General Administration			617
General Expense			1,308
Space Allocation			599
Direct		223	
Indirect		376	
TOTAL INDIRECT COSTS			4,251
TOTAL EXPENSES			13,370
VARIANCE			26

FIGURE 1 – A typical Penn responsibility center budget matrix.

2.31 Formulation of Guidelines

During the Summer and early Fall each year at Penn, guideline principles and parameters are developed and tested, first on a total university basis and then on an individual center basis.

Table 1 illustrates the sort of total University parametric studies performed to test various tuition, compensation, and current expense increases. This data is presented to the Budget Committee to assist in the formulation of guideline recommendations to the President.

TABLE 1 – Projected FY 1977 Unrestricted Budget Performance

	Tuition Increases			Current	Variance
Case	Undergraduate	Graduate	Compensation	Expense	(in 1000 $)
Base – FY 1976	1.0	1.0	1.0	1.0	4492
1	1.04	1.05	1.10	1.06	-1656
2	1.04	1.05	1.10	1.10	-2823
3	1.04	1.05	1.12	1.06	-3026
4	1.04	1.05	1.12	1.10	-4193
5	1.04	1.10	1.10	1.06	-515
6	1.04	1.10	1.10	1.10	-1682
7	1.04	1.10	1.12	1.06	-1885
8	1.04	1.10	1.12	1.10	-3052
9	1.08	1.05	1.10	1.06	-768
10	1.08	1.05	1.10	1.10	-1935
11	1.08	1.05	1.12	1.06	-2138
12	1.08	1.05	1.12	1.10	-3305
13	1.08	1.10	1.10	1.06	373
14	1.08	1.10	1.10	1.10	-794
15	1.08	1.10	1.12	1.06	-997
16	1.08	1.10	1.12	1.10	-2164

Based on these studies the Budget Committee recommends guideline principles and parameters to the President which he in turn presents to the Trustees. Initial guideline principles and parameters for FY 1977 budgets are as follows:

1. The College of General Studies, Summer School, and Wharton Evening School budgets are incorporated into other responsibility centers.
2. Real space charges are held level at 5%.
3. An endowment income overhead fee is levied at 19.1%.
4. University tuition is 10% of earned tuition.

5. Historical smoothing of undergraduate tuition and student aid is applied to responsibility center income as it was in 1976.
6. Organizational issues related to responsibility center definition will be cleaned up.
7. Partial repayment of general fund advances is required.
8. Partial repayment of bank loans is required.
9. Submission of amortization plans for overdrafted restricted accounts is required.
10. The general fee will be better related to the cost of provided services.
11. Group life insurance will be provided to eligible employees as a new benefit.

Initial guideline parameters for fiscal year 1977 assume the effects of the economy and other uncontrollable factors.

1. Current expenses and equipment are assumed to increase by 6% in responsibility centers and 10% in indirect cost centers.
2. Utilities costs are assumed to increase by 10%.
3. Enrollments are assumed constant at FY 1976 levels.
4. Endowment income is budgeted for yield only based on FY 1975 actual experience of $7.49 per Associated Investment Fund share net of direct portfolio management costs and the 19.1% overhead fee.
5. Indirect cost recovery income is budgeted based on Office of Research Administration projections using a 51% rate of which 9.1% is for rollforward, 2.2% for building use and 39.7% for the responsibility centers.
6. Employee benefits rates are computed based on paying for planned increases in benefits costs. New rates are: A-1 @ 15.5%, A-2 @ 21.1%, A-3, 4 @ 20.0%.
7. State appropriation is assumed to increase by 6% and the total increase is reserved as contingency.

Based on the guildeline principles and parameters, the budget office projects alternative controllable program reductions which are required to balance the income/expense budget. Figure 2 illustrates such alternative projections.

Selected guidelines for the 1977 fiscal year are 6% average compensation increase and 7% average tuition increase which requires a 3.3% controllable program reduction for balance.

2.32 Preparation of Outline Budgets

The second phase of the Penn budget process involves two main series of interactions between the central administration and the

		TUITION PLUS FEE INCREASE PERCENTAGE					
		0	1	3	5	7	9
Average Compensation Increase Percentage	0	2.30%	1.85%	0.96%	0.07%	-0.82%	-1.70%
	1	2.98%	2.53%	1.64%	0.75%	-0.14%	-1.02%
	3	4.34%	3.89%	3.00%	2.11%	1.22%	0.34%
	5	5.70%	5.25%	4.36%	3.47%	2.58%	1.70%
	6	6.38%	5.93%	5.04%	4.15%	3.26%	2.38%
	8	7.74%	7.29%	6.40%	5.51%	4.62%	3.74%

FIGURE 2 – Alternative projections of controllable program reductions.

schools. In the first round, the guideline policies and parameters are tested at the individual responsibility center level. Based on the results of the first round, guidelines are reformulated, subvention resources are analyzed, subvention is reallocated and the second round (hopefully) proceeds to balance. Examples of the material employed by the responsibilities centers is presented in a later section of this chapter.

2.33 Preparation of Line Item Budgets

Once agreement is achieved at the outline budget level, the centers prepare detailed line item account budgets. These detailed budgets are then accumulated by the budget office and reconciled against the approved outline budgets.

2.34 Operational Control to Budgets

Information systems for budgeting at Penn support a variety of activities designed to provide operational control of expenditures to budgets. Performance Information is provided to responsibility centers and to the administration. These reports include: monthly accounting system reports by account by ledger; and income-expense reports by school and by departments.

The comptroller and the budget office conduct monthly performance reviews with business administrators and quarterly performance reviews with deans and directors. Information systems also support additional illogical budget analysis and expenditure control actions by the comptroller and the budget office.

Further actions by deans and directors to control expenditures include periodic income reviews and income and expense adjustments for balance.

2.4 Information Systems for Budgeting

At Penn, information systems have been developed for budget planning, budget development, budget approval, and budget control. Since a detailed presentation of the Penn approach to support information systems was published in 1975 by EDUCOM (see reference p. 47), the reader is referred to that proceedings for a full description of the approach.

Penn has made a significant investment in the responsibility center management and accounting system described here. After several years of start up problems the system is in place and functioning well.

3.0 EQUILIBRIUM MODELS: REALISTIC STABILITY

Stanford University and the University of Pennsylvania have each developed approaches to attaining and maintaining a balanced budget and computer based information systems to support those approaches.

Stanford's approach is quite formal, based on detailed projection of future economic behavior, and centrally imposed. A key notion of the Stanford approach is that funded program improvement is closely related to tuition and salaries. The Stanford approach is described in detail in the references (1,2).

At Penn, the notion of equilibrium is central to all budget planning. In the Penn planning and budgeting approach, the concept of realistic stability has been developed and used to describe long term problems. Typically, future planning is done in constant dollars while allowing sufficient contingency to respond to local variations in inflation in various income and expense items. Most planning is decentralized.

At Penn realistic stability is defined as the condition of budget balance where the income is real and continuing and expenses have not been artificially reduced by deferring needed salary increases and other expenditures. Once realistic stability is achieved, it should be possible to retain realistic budget balance in future years through modest changes in controllable income and expense items. However, long term constraints will need to be exercised to assure maintenance of stability.

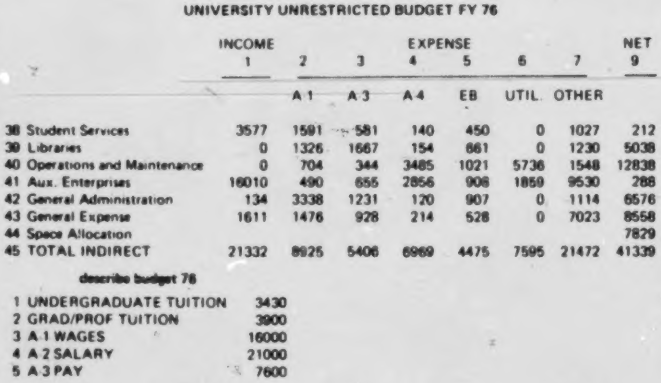
3.1 Example Calculation

Refer to FY 1976 unrestricted outline budgets for responsibility and administrative services centers in Figures 3 and 4 respectively. These

UNIVERSITY UNRESTRICTED BUDGET FY 76

1	REVENUE	
2	Tuition	56396
3	undergrad	30895
4	graduate and professional	25501
5	Special Fees	1154
6	Scholarships	0
7	endowed	0
8	gifts	0
9	U.S. government	0
10	other	0
11	GSAS	0
12	Investment Income	823
13	Gifts and Grants	460
14	private	460
15	federal	0
16	other	0
17	Indirect Cost Recoveries	11276
18	Sales and Services	4000
19	Miscellaneous	1327
20	TOTAL DIRECT INCOME	75436
21	Special State Appropriation	5054
22	From General University	29383
23	TOTAL AVAILABLE	109873
24	DIRECT EXPENDITURES	
25	Compensation	44891
26	administration	4613
27	academic	25552
28	clerical	5289
29	service	889
30	employee benefits	8548
31	Current Expense	7593
32	Equipment	173
33	Student Aid	11385
34	undergraduate	8704
35	graduate and professional	2681
36	TOTAL DIRECT	64042
37	INDIRECT COSTS	
38	Student Services	212
39	Libraries	5038
40	Operations and Maintenance	12838
41	Aux. Enterprises	288
42	General Administration	6576
43	General Expense	8558
44	Space Allocation	7829
45	TOTAL INDIRECT	41339
46	TOTAL EXPENSE	105381
47	VARIANCE	4492

FIGURE 3 – University unrestricted outline budget for responsibility centers.



UNIVERSITY UNRESTRICTED BUDGET FY 76

	INCOME 1	EXPENSE 2 A 1	3 A 3	4 A 4	5 EB	6 UTIL.	7 OTHER	NET 9
38 Student Services	3577	1591	581	140	450	0	1027	212
39 Libraries	0	1326	1667	154	861	0	1230	5038
40 Operations and Maintenance	0	704	344	3485	1021	5736	1548	12838
41 Aux. Enterprises	16010	490	655	2856	906	1859	9530	288
42 General Administration	134	3338	1231	120	907	0	1114	6576
43 General Expense	1611	1476	928	214	528	0	7023	8558
44 Space Allocation								7829
45 TOTAL INDIRECT	21332	8925	5406	6969	4475	7595	21472	41339

describe budget 76

1 UNDERGRADUATE TUITION	3430
2 GRAD/PROF TUITION	3900
3 A 1 WAGES	16000
4 A 2 SALARY	21000
5 A 3 PAY	7600

FIGURE 4 – University unrestricted outline budget for administrative service centers.

outline budgets include all known positive contingency funds for FY 1976 but FY 1976 salary and wage adjustments have not yet been included.

The continuing income base for the university is calculated as follows:

Shown Unrestricted Income	131,205	(109,873 + 21,332)
Less Capital Gains Carryforward	−1,125	
Less Applied E.B. Rollforward	−2,220	
Less 1,000 in Medical School I.C.R.	−1,000	
FY 1976 Stable Income	126,860	

The stable expense base is calculated as follows:

Shown Unrestricted Expense	126,713	(105,381 + 21,332)
Less Unrestricted E.B. Rollforward Costs	−1,932	
Plus 10% COL Compensation Increase	+6,857	
Plus 10% Current Expense Increase	+2,906	
Plus 10% Libraries Current Expense	+120	
Plus 200 in Veterinary School Salaries	+200	
Plus Deferred Maintenance	+500	
	135,364	

Based on the calculation of university continuing income base and stable expense base, realistic stability in FY 1976 would require a reduction in total unrestricted costs of 8,504 or 6.3% on an adjusted expense base of 135,364.

3.2 Personnel Expense Reduction Targets

To compute personnel expense reduction percentages that would have been necessary to achieve realistic stability, it is assumed that the total 8,504 in cost reduction is made in uniform personnel reductions. Recognizing that the assumed 10% increases raises the adjusted FY 1976 base compensation costs to $77,773, a reduction of 10.9% in unrestricted personnel expenses would have been required to achieve realistic stability in FY 1976.

4.0 TENURE PLANNING MODELS

Some of the most important planning decisions in higher education relate to tenure commitments. In current dollars, a tenure decision commits approximately $1,000,000 over 30+ years. Generally these commitments are discipline specific.

Long term planning at Penn then has concentrated on tenure planning and its relation to durable resources. The approach described here has been developed by Dr. Robert Zemsky, Director of Institutional Analysis, and Dr. John N. Hobstetter, Associate Provost for Academic Planning at the university.

Topics to be covered include: the concept of tenure planning; special considerations; prudent staffing levels; a composite school example; planned use of the analysis at Penn; and experience to date with the model at Penn.

4.1 The Concept of Tenure Planning

Estimates can be made of school "$_i$" durable income, DI_i, from interpretative analysis of historical income data by category. The present or current fraction of school $_i$ income spent in support of the standing faculty, "P_i", can also be determined. The product of these gives a short term estimate of school durable income available to support tenured faculty. If "S_i" is the average salary of tenured faculty in school $_i$, then the maximum prudent tenure level in school $_i$ is:

$$\frac{DI_i \times P_i}{S_i}$$

4.2 Special Considerations

Analysis is done in constant dollars to avoid the problems and needless complication of inflation projections. To limit the analysis to workable proportions, the historical analysis and projection period are balanced at five years. Projection is based solely on demonstrated, rather than promised, behavior of each responsibility center. Because the projection is based on five years previous performance, the process requires and facilitates a five year subvention plan and commitment.

At Penn the tenure projection analysis will be repeated yearly for a rolling five year plan. It has been, and is expected to be, useful as a tool to focus productive attention on: tenure levels; balance of tenured and junior faculty; balance of faculty and other expenses; and university priority expressed in subvention relation of staffing to resources.

4.3 Prudent Staffing Levels

Using the tenure planning model a five year projection of school faculty by rank can be presented at two extremes. It is assumed in the following example that durable resources not spent on tenure plus non durable resources are invested in assistant professors. These extremes are:

- no new promotions to tenure
- committing all durable resources available for faculty to tenure positions.

How much of the durable resources, which are projected to be available, should be committed to tenure in any school is a matter of administrative policy and judgement. Because the tenure planning model projects the two extremes of investment of durable resources, an administrator can make a better judgement of the appropriate level of investment.

An example of the tenure plan for a composite of several Penn schools is presented in Figure 5.

4.4 Planned Use of Analysis

After verification of historical data, the tenure planning model will be used in a three step process to develop budget estimates. First the President and Provost, through an interactive process, will determine five year subvention distributions with which they are comfortable. Next, the individual schools will be presented with their tenure planning analysis and be asked to submit five year plans indicating how

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PRESENTLY TENURED:	441
TO RETIRE BY 1980:	16
NET CONTINUING TENURED:	425
MAXIMUM FUNDABLE TENURE:	457

TENURE PROFILE IN 1980 IF:

NO NEW APPOINTMENTS TO TENURE				32 NEW APPOINTMENTS TO TENURE		
NUMBER (*)	NET CHANGE	% CHANGE	CATEGORY (1975)	NUMBER (*)	NET CHANGE	% CHANGE
331	43	15	FULL PROFESSOR (288)	331	43	15
94	-59	-39	ASSOCIATE PROFESSOR (153)	126	-27	-18
106	-64	-38	ASSISTANT PROFESSOR (170)	65	-105	-62
531	-80	-13	TOTAL (611)	522	-89	-15

(*) Includes 65 assistant professor positions funded on non-durable income.

FIGURE 5 – Composite school tenure profile for 1980.

they intend to invest the potentially available tenure positions. Based on these submitted school plans, model results, and other analysis, the President and Provost may then authorize tenure positions and/or may reallocate five year subventions to develop attractive opportunities. In no event will model indications of available positions become license to fill those positions without the most searching academic priorities analysis.

For the future, the basic process will be repeated annually. Each summer the historical data base will be updated with the most recent year information, and the oldest information will be discarded. Next, the President and Provost will update their five year subvention plan, possibly reallocating resources in view of more recent information. Finally, the schools will be asked to respond with changes in their staffing plans.

4.5 Experience to Data

Individual school results were not made available to the schools until late Spring 1976. However, at the time this chapter was prepared, several interesting and valuable results had already been achieved. First, there has been a general recognition that tenure positions must be linked to durable resources. Deans are convinced on a university basis, but they have questioned the concept more on a school basis. Second, there is an emerging recognition that tenure is not a right of the best junior faculty, but rather a resource to be employed sparingly to attract the best available scholar — hopefully from within the institution, but not necessarily. The central administration has recognized that the five year subventions mean nothing unless the subvention resources are managed to be constant or increasing and overhead costs are constant or decreasing in constant dollars. The schools have recognized that they can influence tenure availability through income generation and lifestyle. Finally, administrators in the schools have reluctantly accepted the assumption that tenure planning should be on the basis of assured durable resources and not expected resources such as pledges, hoped for grants, and possible future interschool reallocation.

5.0 LONG TERM BUDGET PLANNING AT PENN

At the University of Pennsylvania tenure planning is the principle focus of long term planning, but the following issues deserve attention in their own right:

1. Maintenance of General University Income
2. Compensation Planning
3. Tuition and Other Student Costs Planning
4. Total Return on Investments
5. Effect of Federal Policies on Support of:
    a) Health Related Instruction
    b) Research (by discipline)
6. Costs of Overhead Services
    a) Uncontrollables (energy, interest, insurance)
    b) Regular Services
    c) Coupling to Federal Overhead Policy
7. Overhead on Restricted Activities
    a) Research
    b) Endowment
    c) Other
8. Funding Development Costs
9. Managing Development Campaign Proceeds
10. Sizing Overhead Services

Long term budget planning at the university will take all of these issues into account.

References

1. R.F. Bacchetti and W.F. Massy, "The Budget Equilibrium Program — Why it is needed, what has been accomplished, and what remains to be done", *Campus Report,* Stanford faculty & Staff Newsletter, Vol. VIII, No. 15, January 7, 1976.

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CHAPTER 7

by A.J. ROSE

Use of APL in Administrative Systems

APL, since it first became available as a computer programming language in 1966, has been the center of many heated arguments. Its detractors who favor the classical computer language such as COBOL and Fortran have said that APL is too unstructured and too cryptic (some have even said that it is too powerful) to be commercially viable.

Its advocates praise APL for the same reasons. Because it is compact, one level of structure is subsumed by the power of its primitive operations. Because it is symbolic, it is independent of any natural languages and, moreover, lends itself to formal algebraic manipulation (and, hence, optimization).

In the 1960's, APL could be discounted as not commercially viable because it did not handle either files or commercial formatting. But in the interest of survival, commercial time sharing companies developed file systems and formatting routines for APL, and the acceptance of APL in the business community is now well established. We repeatedly hear and see cases where using APL significantly reduced the amount of time required to implement a computer application – reduced times of a factor of 4 to 10 are not uncommon.

Moreover, there is empirical evidence that APL is gaining in the academic community:

- Syracuse, UCLA, and Wharton all use APL in their business curriculum.
- It is estimated that over 400 colleges in the U.S. provide some sort of access to APL.
- There are around ten textbooks on APL available, and one of the more popular ones regularly sells over 25,000 copies per year.

APL is used for a variety of administrative functions at Orange Coast Community College, Syracuse, SUNY (Harpur), University of Texas (Dallas), Cornell Medical, Quebec, UCLA, among others. Many of the applications had grass roots beginnings in that they were developed by a faculty member or department administrator with a need and interest, rather than by the central data processing or MIS staff. That has also been the typical history in the commercial world.

The workshop was used to teach APL, rather than to talk about it. The outline used was the Table of Contents of "APL, An Interactive Approach" by Gilman and Rose (Wiley, 1974), with particular emphasis on Chapters 21 (Formatting) and 20 and 30 (Files).

A feeling for APL's compactness and power can be gotten from the following sample terminal session:

1.0 DESK CALCULATOR OPERATIONS

```
      82                  User input indented
82                        Response not indented

      2+5                 Add scalar to scalar
7

      4-6                 Subtract
¯2

      678×23.4            Multiply
15865.2

      5÷7                 Divide
0.7142857143

      )DIGITS 16          Change display to 16 places
WAS 10
      5÷7
0.7142857142857143        Internal precision is 16+
      )DIGITS 10
WAS 16
```

2.0 OPERATIONS EXTEND TO VECTORS

```
      2+2 4 7 3 2         Scalar to vector
4 6 9 5 4

      2 4 7 3 2+2         Vector to scalar
4 6 9 5 4

      3 4 5+6 7 8         Vector to vector
9 11 13
```

```
      Y←2 4 7 3 2          Y is assigned the value
      Y                      of the expression
2 4 7 3 2
      Y×Y                  Y squared
4 16 49 9 4

      2+4+7+3+2            Sum
18
      +/2 4 7 3 2          Plus-reduction,
18                           or vector sum
      +/Y                  Plus-reduction of Y,
18                           or sum over Y
      ×/Y                  Times-reduction of Y,
336                          or product over Y

      ⌈/Y                  Maximum in Y
7
      ⌊/Y                  Minimum in Y
2
      (⌈/Y)-⌊/Y            Range in Y
5

      +\Y                  Plus-scan operator,
2 6 13 16 18                 or cumulative sum

      2↑Y                  Take first 2 elements
2 4
      ¯3↑Y                 Take last 3 elements
7 3 2
      1↓Y                  Drop first element
4 7 3 2
      ¯1↓Y                 Drop last element
2 4 7 3

      ⍳6                   Index generator
1 2 3 4 5 6
```

3.0 OPERATIONS EXTEND TO ARRAYS

```
      A←'ABCDEFGHIJKL'
      ⍴A                Shape of A
12
      3 4⍴A             Reshape into 3 rows, 4 columns
ABCD
EFGH
IJKL
      B←2 3⍴⍳6
      B
 1 2 3
 4 5 6
      C←4 2 7 1 5 8
      C←2 3⍴C
      C
 4 2 7
 1 5 8
```

```
      B+C                Operation on arrays
 5  4 10                   element-by-element
 5 10 14

      B×C
 4  4 21
 4 25 48

      B=C                Relational operators <≤=≥>≠
0 1 0
0 1 0

      B>C
0 0 0
1 0 0

      B,C                Arrays catenated (chained)
1 2 3 4 2 7                along rows
4 5 6 1 5 8

      B,[1]C             Arrays catenated along columns
1 2 3
4 5 6
4 2 7
1 5 8

      B←⍉B               Transpose of matrix B
      B
1 4
2 5
3 6

      B+.×C              Matrix product
  8 22 39
 13 29 54
 18 36 69

      B[2;2]             Elements of arrays may be selected
5
      B[3;1]←0             and changed

      M←1 2 ¯3 2 ¯1 2 1 1 ¯1
      M←3 3ρM            Simultaneous linear equations:
      M                      x+2y-3z=-9
  1  2 ¯3                   2x- y+2z=16
  2 ¯1  2                    x+ y- z=-1
  1  1 ¯1
      V←¯9 16 ¯1           solved by dividing vector of
      XYZ←V⌹M              constants by matrix of coefficients
      XYZ
4 ¯2 3
      M+.×XYZ            Check - multiply M by answers
¯9 16 ¯1                   to get V.
```

4.0 EXAMPLES OF USEFUL FUNCTIONS IN THE APL* PLUS SYSTEM

4.1 Sort Numbers

Sort in ascending order.

```
      X←18 7 26 ¯1 5 10 ¯4
      X[⍋X]
¯4 ¯1 5 7 10 18 26
```

Sort in descending order.

```
      X[⍒X]
26 18 10 7 5 ¯1 ¯4
```

4.2 Hypotenuse of a Right Triangle

```
      ∇HYP[⎕]∇
    ∇ C←A HYP B
[1]   C←((A*2)+B*2)*0.5
    ∇

      3 HYP 4
5

      3 1 5 HYP 4 1 12
5 1.414213562 13
```

4.3 Polynomial Evaluation

Consider polynomial: $Y=3X^4-9X^3+4X+13$
Its coefficients are: 3 -9 0 4 13

```
      ∇POLY[⎕]∇
    ∇ R←C POLY X
[1]   R←(((⍴X),1)⍴X)⊥C
    ∇

      C←3 ¯9 0 4 13

      C POLY 1
11

      C POLY 10
21053
```

```
      X←2 3⍴1 10,⍳4
      X
1 10  1
2  3  4

      C POLI X
   11 21053     11
   ¯3    25    221
```

4.4 Sort Characters

Any collating sequence may be used.

```
        ∇SORT[⎕]∇
      ∇ R←COLL SORT M
[1]     R←M[⍋(1+⍴COLL)⊥⍉COLL⍳M;]
      ∇

        CITIES
WASHINGTON
HARTFORD
NEW YORK
PHILADELPHIA
BOSTON
PITTSBURGH
DALLAS
LOS ANGELES
PALO ALTO
SAN FRANCISCO

        ALF←'ABCDEFGHIJKLMNOPQRSTUVWXYZ'

        CITIES←ALF SORT CITIES
        CITIES
BOSTON
DALLAS
HARTFORD
LOS ANGELES
NEW YORK
PALO ALTO
PHILADELPHIA
PITTSBURGH
SAN FRANCISCO
WASHINGTON
```

4.5 Table Lookup

Given a table of character data (*CITIES*) and a table of possible new entries (*NEWCITIES*), see if the new entries are already in the table and, if so, where.

```
      ∇TLU[⎕]∇
    ∇ R←T TLU N
[1]   R←(⍳1↑⍴T)+.×T∧.=⍉N
    ∇

      NEWCITIES
CHICAGO
BOSTON
HOUSTON
WASHINGTON

      CITIES TLU NEWCITIES
0 1 0 10
```

Try [illegible] other way around.

```
      [illegible]CITIES TLU CITIES
2 0 [illegible] 0 0 0 0 0 4
```

4.6 Using Large Files

```
      )LOAD 1 FILES
SAVED  . . .
      'SAMPLEFILE' FCREATE 1          Create file 1 named SAMPLEFILE
      'ALPHA DATA' FAPPEND 1          Place new component on file 1 with character data
      (⍳1000) FAPPEND 1               First 1000 integers become component 2 of file 1
      'ABCDEFGHI' FAPPEND 1           Place character data into component 3
      (?35 27⍴99999) FAPPEND 1        Array of random data into component 4
      FREAD 1 1                       Read file 1 component 1
ALPHA DATA
      ¯5↑FREAD 1 2                    Take last five elements of file 1 component 2
996 997 998 999 1000
      +/FREAD 1 2                     File operations can be used within larger expressions
500500
      ⍴FREAD 1 4                      Read and check size of contents of component 4
35 27
      (FREAD 1 4)[26;8 2 14]          Look at three elements
43045 76234 51934
      (?12⍴9) FREPLACE 1 1            Replace component 1 with 12 random integers
      FREAD 1 1
9 1 9 2 9 5 3 7 6 8
      FLIM 1                          What are the limits of file 1?
1 5                                   First component is #1, next to go in will be #5
      FDROP 1 2                       Drop the first two components of file 1
      FLIM 1
3 5                                   First component is now #3
      FDROP 1 ¯1                      Drop the last component
      FLIM 1
3 4                                   Next to go in will be #4
```

4.7 Report Formatting (Δ*FMT*)

```
      NUMERICS
 336067.35       ¯446867.1          7906.35          237.4
 ¯66509                  0           223.4          ¯84.556
¯100209.4             8130          1235.6       867552.45

      ALPHA
ITEM1
ITEM2
ITEM3

      ⍝ COMMA INSERTION, ZERO SUPPRESSION, FIELD WIDTH OF 20, 2 DECIMAL PLACES.

      'CBF20.2' ΔFMT NUMERICS
         336,067.35        ¯446,867.10            7,906.35              237.40
         ¯66,509.00                                 223.40              ¯84.56
        ¯100,209.40           8,130.00            1,235.60          867,552.45

      ⍝ COMMA INSERTION, ZERO SUPPRESSION, FLOATING DOLLAR SIGN, PARENTHESIZE NEGATIVES,
      ⍝ FIELD WIDTH OF 20, 2 DECIMAL PLACES.

      'CBF<$ >Q< >M<(>N<)>F20.2' ΔFMT NUMERICS
       $ 336,067.35       (446,867.10)         $ 7,906.35            $ 237.40
         (66,509.00)                             $ 223.40              (84.56)
        (100,209.40)        $ 8,130.00         $ 1,235.60        $ 867,552.45

      ⍝ ALPHABETIC FIELD, SEPARATORS, SPLIT FIELDS ... ONE WITH COMMA INSERTION, ZERO SUPPRESSION,
      ⍝ MIDDLE BAR INSERTED FOR NEGATIVES, THE OTHER WITH COMMA INSERTION, FLOATING DOLLAR SIGN.
      ⍝ FOLLOW CREDITS AND DEBITS WITH CR OR DB OVER A FIELD OF 20 WITH 2 DECIMAL PLACES.

      '5A1, < ** >, 2CBM<->I15, 2CP<$ >Q< CR>M< >N< DB>F20.2' ΔFMT (ALPHA,NUMERICS)
ITEM1 **         336,067        -446,867       $ 7,906.35 CR         $ 237.40 CR
ITEM2 **         -66,509                         $ 223.40 CR            84.56 DB
ITEM3 **        -100,209           8,130       $ 1,235.60 CR     $ 867,552.45 CR

      ⍝ SAME AS ABOVE BUT WITH A PHRASE INSERTED FOR ZERO OCCURRENCES.

      '5A1, < ** >, 2CBM<->N<             NONE>I20, 2CP<$ >Q< CR>M< >N< DB>F20.2' ΔFMT (ALPHA,NUMERICS)
ITEM1 **              336,067             ¯446,867        $ 7,906.35 CR          $ 237.40 CR
ITEM2 **              -66,509                 NONE          $ 223.40 CR             84.56 DB
ITEM3 **             -100,209                8,130        $ 1,235.60 CR      $ 867,552.45 CR

      ⍝ TODAY'S DATE.                                          ⍝ CURRENT TIME.
      'G<99/99/99>' ΔFMT 825                                  'G<99:99:99>' ΔFMT 100⊥3↑2↓ 60 60 60⊤820
08/07/75                                                   12:16:15

      ⍝ PHONE NUMBER
      'G<PHONE (999) 999-9999 X999>' ΔFMT 3016578220263
PHONE (301) 657-8220 X263
```

CHAPTER 8

by ROB GERRITSEN and MICHAEL D. ZISMAN

Database Management Systems

1.0 INTRODUCTION

The term "database management" or "database management system" conveys different meanings to different people. In the author's view, a general purpose database management system (DBMS) should provide a large subset of the following functions:

- File and data structure definition
- View definitions (sub-schemas)
- Database creation (loading)
- Database maintenance (update)
- Database query (retrieval and summarizing)
- Report generation (formatting breaking summarizing)
- Procedural interface (to COBOL, FORTRAN, PL/1, etc.)
- Security and privacy (passwords, encoding, audit)
- Database sharing

Figure 1 illustrates a general architecture of such a database management system.

After discussing the importance of structure to database management, this chapter considers the value of file management systems for simplified updating, retrieval, and report generation. The chapter concludes with a discussion of database design principles illustrated with an example.

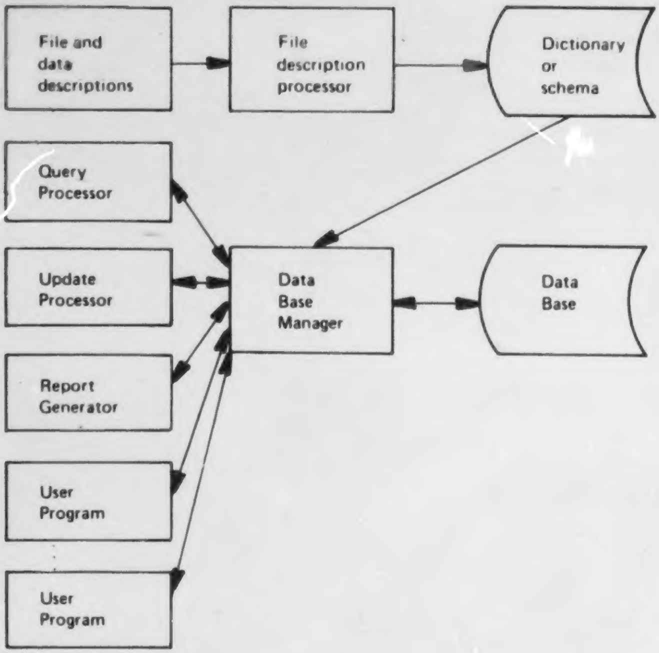

FIGURE 1 – General architecture of a database management system.

2.0 DATA STRUCTURE

The structure of data is very important in data base management. One of the basic functions of any database management program is to maintain the integrity of the data structure in the database, and to utilize the data structure in retrieval. To accomplish these objectives, a database management system must describe the structure of files and data to the database management program. The schema is such a description.

In any schema there are several levels of structure, each of which can be described in terms of the next lower level. Levels of structure of a typical database management system range from the highest, database, to the lowest, the bit. Figure 2 illustrates such a hierarchy.

DATABASE*
FILE
RECORD*
SEGMENT
GROUP ITEM
ITEM, FIELD, ATTRIBUTE*
CHARACTER, BYTE
BIT

*Indicates the most useful levels of description.

FIGURE 2 – Schema of a typical database management system.

It is possible to describe the structure of an EMPLOYEE record as the composition of two segment types, a root segment and a dependent segment, with the stipulation that a record must always contain exactly one root segment and can contain any number of dependent segments. This schema describes a typical *variable length* record structure.

Each segment of the variable length record structure can be described in terms of its component items. For example, the root segment of the EMPLOYEE record might contain EMPNO, EMPNAME, SEX, DEPCOUNT; the dependent segment might contain DEPNAME and RELATIONSHIP. Figure 3 illustrates a record which contains one root and two dependent segments. This schema is called an intra-record structure.

EMPNO	EMPNAME	SEX	DEPCOUNT	DEPNAME	RELAT	DEPANME	RELAT
145	Smith	M	2	Sue	wife	Joe	son

FIGURE 3 – Intra-record structure: a variable length record with one root and two dependent segments.

Rather than using variable length records, it is possible to store the same information by using two records, an EMPLOYEE record and a DEPENDENT record. Figure 4 illustrates this approach.

The use of inter-record structure rather than intra-record structure requires *pointers* (in this case to point from an employee to each of his

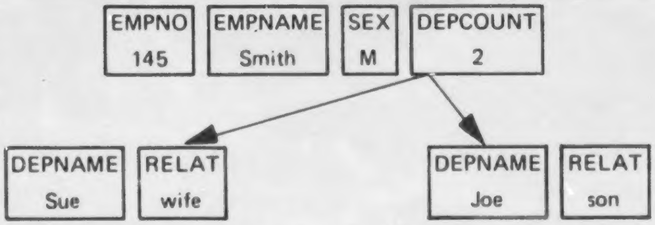

FIGURE 4 – Inter-record structure: a fixed length record with inter-record pointers to dependent records.

or her dependents). It is the database management system's responsibility to maintain these pointers for the user. Pointers can be used in two primary ways: as a pointer array; or as a chain. In the pointer array, illustrated in Figure 4 one pointer is used for each dependent associated with an employee. If the pointers in this case were used the first would point from the employee to his or her first dependent. The second points to the next dependent, and so on.

If DBMS supports an inter-record structure, it is typically called a *hierarchical* or *network* DBMS. The principal distinction of a network DBMS is that it permits a record to participate in more than one hierarchy. This is useful because it permits the database to capture the complex interrelationships between data that correspond to the interrelationships that occur between the entities that the data describe. Database users are saying the same thing when they say that a network DBMS permits minimum data redundancy.

For example, add PROJECT records to the example database containing EMPLOYEE and DEPENDENT records. Just as any employee can have any number of dependents, he or she can be working on any number of projects. However, a project differs from a dependent in that any number of employees can be working on a project; whereas a dependent can be dependent on only one employee (assuming that the company has a strict nepotism policy). In general, relationships such as the one between EMPLOYEE and DEPENDENT are called one-to-many, and relationships such as between EMPLOYEE and PROJECT are called many-to-many. The term "functional dependency" is frequently used by some in place of our term "relationship".

Continuing with this example, note that there exists useful information about the work of a particular employee on a given project, such as total budgeted time, time spent on the project to date by the employee, the employee's schedule on the project, etc. Call a record containing such information the TIME record. To describe a one-to-many relationship between EMPLOYEE and TIME and also a one-to-many relationship between PROJECT and TIME, a diagram like the one in Figure 5 is useful.

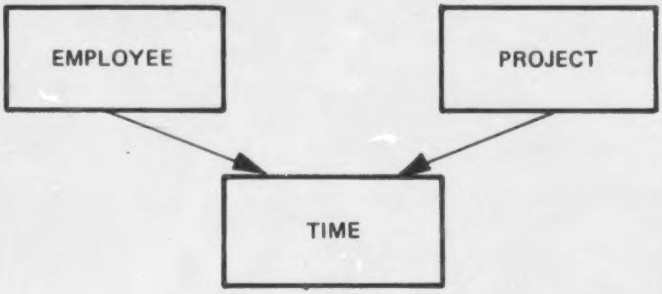

FIGURE 5 – A schema to illustrate two one-to-many relationships.

This structure not only captures the two one-to-many relationships (EMPLOYEE-TIME and PROJECT-TIME), but it also captures the many-to-many relationship between EMPLOYEE and PROJECT! Namely, from the EMPLOYEE's viewpoint it is possible to associate a unique PROJECT with each of the many associated TIME records; similarly, a unique EMPLOYEE can be associated with each TIME record associated with a PROJECT.

A structure such as this, using two hierarchies to represent a many-to-many relationship, is called a *confluency*. Many people, when first introduced to this structure, suspect that the base record of the confluency (TIME in our example) is a *dummy* record, present only to enable the relationship to be captured. In the authors' experience, this is *not* the case. In the example, the TIME record definitely has its own purpose, and the same can be said for a GRADE record in a STUDENT-COURSE confluency, or a PRICE record in a SUPPLIER-PART confluency. We leave discovery of the contents of the base record in a DOCTOR-PATIENT confluency to the reader.

3.0 IMPROVEMENTS AT THE USER'S INTERFACE

In order to use a DBMS effectively, users need some mechanism for communicating to the DBMS and for receiving responses from it. This can be accomplished with a high level host computer language, such as COBOL or PL/1, or via a file management system such as MARK IV or GIS. While a file management system (FMS) can be used on a stand-alone basis (with no underlying DBMS) as a very effective applications development tool, many commercial file management systems can be used in conjunction with a DBMS. In this mode, the file management system acts as a translator and "buffer" between the user and the DBMS. Figure 6 illustrates this relationship.

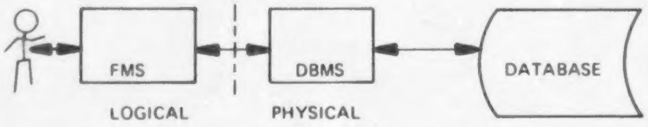

FIGURE 6 – A file management system functions as a buffer between user and DBMS.

A file management system allows the user to deal with a logical view of the data without concern for how or where the data is actually stored or with the detailed command structure of the DBMS. The DBMS, on the other hand, is concerned with the physical storage and subsequent retrieval of data. Using a file management system, a user can create and maintain a database that is stored under the DBMS as well as generate reports from the database. Additionally, the file management system has extensive data editing facilities to assure the integrity of the data entered into the database.

As implied above, most file management systems include report generators that assist the user in processing the database and generating reports. Such report generators have the capability to select data from the database, sort the selected data and print reports that can include summaries and control breaks.

Many of the commercially available report generators are designed to produce tabular output but some do have the capability for the user to specify "free-form" reports. By using a report generator of this nature, non-data-processing personnel can interact directly with the database to prepare ad hoc reports. While this capability can dramatically improve the productivity of both the DP and non-DP personnel, security considerations must be weighed heavily in such an environment.

Although not common today, a file management system, coupled with a DBMS, can completely replace high level computer languages for applications development. It is reasonable to expect this trend to continue into the future.

4.0 DATABASE DESIGN

In designing a database structure, the designer models the organization which the database serves. To do this the designer must determine which data is to be stored in the database, and what relationships, or functional dependencies, exist between the data elements. The functional dependencies should be classified as one-to-one, one-to-many, many-to-many or recursive hierarchies. Once this process is complete, a data structure diagram can be constructed which accurately reflects the user's view of the data. Finally the designer may wish to add or remove data elements and functional dependencies to increase the efficiency in processing the database.

As an example, consider a student records database and concentrate on the course records portion of that database, as opposed to student personal information. In a gross sense, data in this database will consist of data about students, data about courses, and data about faculty members teaching these courses. More specifically, data will include:

- Student identifying information – a record for each student.
- A record for each course offered.
- A record for each department offering courses.
- A record for each college that has departments offering courses.
- A record for each classroom where courses are taught.
- A record for each faculty member teaching courses.
- Data about the courses that each student is taking.
- Data about the courses each faculty member is teaching.
- Data about course pre-requisites.

From this, the designer can deduce the following functional dependencies:

- student-course; *many-to-many*
- course-faculty; *many-to-many*
- faculty-student (advising); *one-to-many*
- faculty-student (supervising); *one-to-many*
- course-course (pre-requisite); *recursive hierarchy*
- dept.-faculty (appointment); *many-to-many*
- college-dept.; *one-to-many*
- dept.-course; *one-to-many*
- room-course; *one-to-many*

Building on the set of functional dependencies, the designer can construct a data structure diagram. One possible schema is illustrated in Figure 7. Note that the authors have already "designed in" constraints. For example, a course can be offered by only one department in this model.

While the data structure illustrated in Figure 7 includes all of the data relationships mentioned above, it may prove inefficient for some processing modes. For example, to produce reports showing faculty and students in their courses, the present data structure requires that one "navigate" through the course records. As an alternative, the designer could add a new relationship that directly links the student and faculty records as shown in Figure 8. This data structure will allow users to produce a faculty-student report much more quickly because they can navigate directly from faculty records to student records.

Many such trade-offs need to be considered and refinements must be made to this example data structure before it could be considered complete. One major trade-off that must always be considered is the cost of retrieval versus the cost of update. As functional dependencies are added to decrease the retrieval time, almost always the time required to update these records will increase since there will be more relationships to maintain. The only way to make these trade-off decisions is to estimate the expected volumes of retrievals and updates

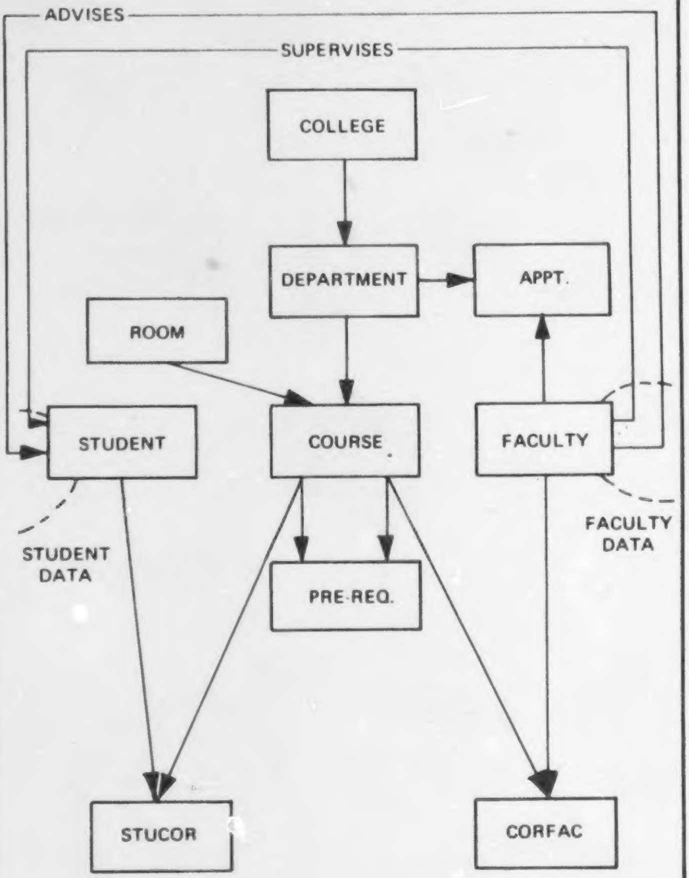

FIGURE 7 – Data structure for a student-course database.

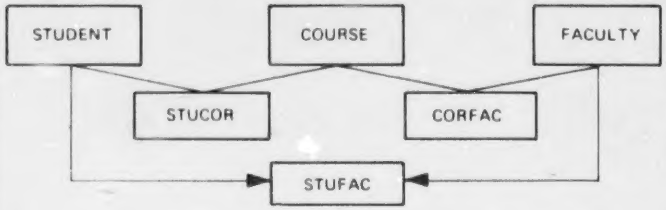

FIGURE 8 – Alternative data structure for student-course database.

and then determine whether or not the additional relationships would be cost effective.

CHAPTER 9

by DUANE E. WEBSTER and JEFFREY J. GARDNER

Strategies for Academic Library Management

1.0 A SYSTEMS VIEW OF LARGE LIBRARIES

The nature of large, academic and research libraries is currently undergoing fundamental change. As economic pressures facing all of higher education continue, the historical nature of these libraries as collectors and holders of the world's intellectual output may no longer be viable at individual campuses. In any case, it has become apparent during the decade of the seventies that the fundamental mission of these institutions will undergo substantive review in future years.

One model for conceptualizing these challenges to academic libraries, presented in Figure 1, treats the nature of large libraries in terms of the input (i.e. resources) required to operate them, the managerial processes utilized in their operation, and the expected outputs from those processes. In the past, particularly during the post-war period from the early 1950's through the late 1960's, the allocation of resources in academic libraries took place in an environment of expansion. New, impressive facilities were constructed, research collections grew in various locations and the additional staff required to service these facilities and collections were hired. However, as higher education moved from a period of growth toward a period of stabilization or decline, the nature of this process began to change. Library management decisions were no longer "where to expand", but rather, "where to cut".

Similarly change has taken place in library management processes because tasks related to maintaining rapidly growing collections are quite different from those of managing decline. Library organizational structures which emphasized a split between building collections and providing traditional reference and circulation services to users are now being rethought. While that basic structure continues to predominate, new structures which emphasize libraries' service objectives are being tried. Administrators of large libraries are discovering that they require

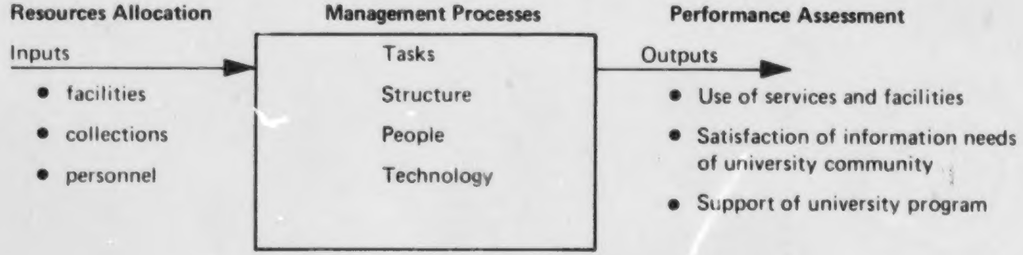

FIGURE 1 – A Systems View of Large Libraries

new staff skills and expertise. In a period of economic decline it has become important to develop skills among existing staff through extensive training and development programs. Academic libraries are also increasingly aware of the need for non-library technical skills in areas such as long-range planning, budgeting and computer systems. Finally, the availability of new technologies has begun to provide substantive opportunities for changing the ways in which large libraries allocate their human resources. Some obvious examples of technological impact are on-line, shared cataloging networks and computer-based bibliographic searching. Other applications using microform and communication technologies provide similar challenges.

The changes in library management cited above effect, and are effected by some perceptible shifts in emphasis in library outputs. Building and maintaining comprehensive and distinctive research collections is no longer a viable alternative for most large academic libraries. Costs of library materials have risen faster than library budgets. (See Figure 2.) At the same time, the degree and diversity of library user needs and demands have increased. In this context, individual libraries and the national library community are working toward the development and utilization of new techniques and mechanisms for the delivery of information services to their users. In some cases, changes will be local; in others they will be cooperative and/or collective. New developments in communication networks for interlibrary loan and movement toward national and regional lending libraries illustrate this process.

2.0 PRESSURE FOR CHANGE

Within the context of the preceding discussion, consider the pressure, particularly environmental forces, working for change within academic libraries. Major pressures include the following:

- *Changes in higher education.* These include: changing goals of colleges and universities which reflect their adaptation to the changing needs of society; declining enrollments at many colleges and universities reflecting both demographic factors and a degree of disillusionment with higher education; declining public support of higher education which apparently reflects an attitude that higher education is not a priority national concern; changing nature of student bodies, more directly career-oriented and concerned with jobs than previously; and, finally the growing economic problems facing all of higher education;

Year	Books (Hard Cover)	Periodicals	Serials Services	Library Expenditures for Materials
% Increase From 1974 to 1975	12.8%	13%	8%	5.5%
% Increase From 1971 to 1975	19.9%	71%	32%	23.5%

From 1971-75, annual expenditures for library materials at ARL libraries increased 23.5%; number of volumes added decreased 7%.

FIGURE 2 – Percent Increase of ARL Library Expenditures for Material vs. Materials Price Increases*.

*Figures based on: Atkinson, Hugh C. "Prices of U.S. and Foreign Published Materials," in *The Bowker Annual of Library and Book Trade Information* (1975) R.R. Bowker Co., pp. 176 186.

- *Changes in the information community.* In recent years libraries have seen the costs of library materials, both books and periodicals, increase beyond their budgets. Indeed, in many instances library budgets have declined and in a majority of libraries their buying power has decreased in spite of modest budget increases. Combined with these factors is the continued growth of the publishing industry's output and the introduction of new but costly forms of publishing, such as machine-readable bibliographic data bases;

- *Changing demands of library users.* During this period of retrenchment, users of academic libraries have not diminished their needs or demands. While timely access to materials remains a primary concern, increased specialization and the current emphasis on independent study and research programs increases the difficulty of fulfilling even this basic function. Demands for increased hours, more duplicate copies of course-related material and more conveniently-located departmental libraries are not unusual. The need for the revitalization of the library as an instructional institution has produced additional demands on already over-extended public service staffs.

Recognize that two sets of forces are seemingly in conflict. On the one hand there are forces which are working for libraries' emphasis of new roles by developing a commitment to new or enhanced services. At the same time, academic libraries are faced with declining financial and organizational support. In this situation academic libraries have four general options: to ignore the external world and do nothing; to withdraw from those pressures which are most discomforting; to adapt to changes as they occur; or, to develop a stance of influencing the environment while adapting to irreversible changes. While situations vary, it seems clear that the first two options are simply not viable. The third, while viable, is weak. The fourth option provides the best opportunity for rational, constructive change.

3.0 PLANNING ASSUMPTIONS

In light of pressures for change in academic libraries, a series of planning assumptions are useful to determine new directions for academic libraries. Some assumptions developed during the EDUCOM Spring 1976 Conference are:

- The economic situation is probably not going to improve very soon.

- Private institutions in particular may face worse financial problems.
- It will be increasingly difficult to maintain current research collections and provide services required by local users.
- Distinctive research collections, which in the aggregate represent the world's cultural and intellectual history, must be supported, but which ones and how remain questions.
- Technology must be applied effectively and rationally.
- Techniques for measuring library costs and outputs need to be developed.
- Difficult decisions on what can be done well and what cannot be done well confront academic libraries.
- More successful, meaningful ways to cooperate and share resources will have to be developed.
- Libraries must develop and adopt more realistic collection development policies.
- There is a need for many, if not most, libraries to move from an emphasis on holdings to an emphasis on access.
- Self-sufficiency is not possible.

4.0 A WORKSHOP CASE STUDY

A case study exercise, in which workshop participants can advise the case institution is often helpful to focus a planning effort. The case study illustrated by Figures 3 – 6 is a composite of several actual situations. There are no answers which are specifically defined as "correct". Rather, the case is intended to focus discussion on some critical issues facing libraries in the mid-1970's. The exercise has three steps: reviewof strategic options; choice of tactical plans; and review of plan rationale. In the first step, groups of four or five participants review the three strategic options on Worksheet I (Figure 4), list the advantages and disadvantages of each and reach a consensus on which option is likely to be the most effective. In step two, participants review fourteen tactical steps, presented in Worksheet II (Figure 5), *Case Study* *

A large, private university is faced with serious budgeting problems. The preceding year's deficit was fifteen percent and the university's administration has identified balancing the budget as a primary objective for the coming year. The student body of 11,000 is approximately half graduate students, and about half of them are in Ph.D. programs representing 40 fields of study.

The university's library is a major research library with extensive collections in support of the institution's graduate and research programs. It has 2,000,000 volumes, added 100,000 volumes in the preceding year, maintains 33,000 serial subscriptions, has a staff of 90 professional librarians and 210 non-professionals. Last year its total expenditures were $4.5 million; $2.5 million of which went for salaries; $1.6 million for books and serials.

The library director has just received notice that the library faces a budget cut of 15 percent ($675,000) for the coming year. The library must develop, first, a broad strategy for dealing with this situation. The attached worksheet presents some strategic options; consider these in terms of their advantages and disadvantages.

FIGURE 3 – Exercise on operating in a period of financial decline©.

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which might be considered for implementing a strategy of making selected budget cuts within a major academic library. Again, groups of 4 or 5 participants must reach concensus on whether each tactical action is preferred, possible, or unacceptable. Finally, in step three participants use Worksheet III (Figure 6) to list the criteria, or rationales, which were implicit in the decisions reached in step 2.

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*Designed by: Association of Research Libraries, Office of University Library Management Studies.

OPERATING IN A PERIOD OF FINANCIAL DECLINE: WORKSHEET I

As a group, discuss the advantages and disadvantages of the strategies listed below, then reach agreement on which is best.

Strategic Options	**Advantages**	**Disadvantages**
1. Strategy of resistance and political pressure: this strategy would be aimed at overturning the decision and might include such tactics as: mobilizing faculty and other user pressure on university administrator by personal contact, campus newspaper interviews, cutting services to cause user uproar, etc.		
2. Strategy of applying a 15% budget cut across the board to all library departments.		
3. Strategy of making selective budget cuts according to some specified criteria.		

FIGURE 4 – Case Study, Worksheet I.

OPERATING IN A PERIOD OF FINANCIAL DECLINE: WORKSHEET II

Assuming that the 15% budget cut is irreversible and that the library has chosen option 3, to make selected budget cuts, indicate which of the following actions would be preferred, which might be useful, and which would be unacceptable.

Actions	**Preferred**	**Possible**	**Unacceptable**
1. Inform staff and library administration of impending cuts and secure information on the impact of the possible cuts on individual library departments.			
2. As director, develop budget cut implementation plan confidentially, so as not to upset staff.			
3. Go to library department heads and request information on: where cuts can be made; impact of possible cuts on internal operations and library services; how much can be saved by specific cuts and how specific cuts might be implemented.			
4. Establish representative professional staff committee to prepare a report recommending where cuts can be made.			

FIGURE 5 — Case Study Worksheet II

Actions	Preferred	Possible	Unacceptable
5. Do a user inquiry/survey concerning what are most/least important services as a way of determining what will be cut.			
6. Focus on eliminating selected activities such as: original cataloging; foreign language cataloging; departmental libraries; decentralized reserve book collections; telephone reference service; etc.			
7. Focus on increasing income by charging or increasing fees for selective, specialized services, such as: charges to non-affiliated users; charges for interlibrary loan requests; charge for computer-based search services.			
8. Focus on reducing services by cutting hours and/or staff levels at public service desks.			
9. Focus on reducing serials budget, e.g. by eliminating duplicate subscriptions, reducing number of titles, eliminating standing orders from university presses.			

FIGURE 5 – Continued

Actions	Preferred	Possible	Unacceptable
10. Focus on reducing book (i.e. monograph) budget, e.g. by eliminating duplicate copies, reducing subject area coverage, reducing purchase of foreign language material, etc.			
11. Focus on reducing personnel costs, e.g. by maintaining current salary levels, freezing hiring, reduction in force, elimination of part-time staff.			
12. Focus on reducing facility and equipment expenditures.			
13. Focus on resource sharing be developing cooperative programs.			
14. Postpone planned projects and facilities such as new departmental library, new automated circulation system, etc.			

FIGURE 5 – Continued

OPERATING IN A PERIOD OF FINANCIAL DECLINE: WORKSHEET III

On Worksheet II, some actions were checked as preferred. Implicit in those decisions were some criteria, or rationales. As a group, develop a list of all of the criteria for deciding on which approach(es) to use in cutting the library's budget.

Criteria for Decision-making

FIGURE 6 – Case Study, Worksheet III

5.0 SUMMARY OF CASE STUDY DISCUSSIONS

In the discussions of Worksheet I at the EDUCOM Spring 1976 Conference, participants focused on coming to terms with the reality of managing libraries during a period of financial decline. The strategy of resistance and political pressure was determined to be unlikely to succeed, time-consuming, and possibly destructive to library relations with university administrators. In addition, since the entire university shared the financial crisis, participants agreed that the library had a positive responsibility to cut costs. However, there was considerable feeling that, while the option was not viable as a sole, or even primary strategy, that it was important to make clear to the university community what the impact of this budget reduction would be and what future budget reductions would do to the library's current service and collection programs.

While the option of applying a fifteen percent, across the board cut offered the advantages of being easy, quick, and superficially equitable, the option was dismissed by the workshop participants as being fundamentally irrational. As a process, it would overlook the opportunity for a constructive review of the library programs and activities and would avoid the issue of library outputs: what they are, what they cost, and what they are worth. Finally, the process would make no distinction between frills and essential services, cutting both equally.

The third option, making selective budget cuts according to some specified criteria, was selected by the workshop participants as the most effective. It would provide for a systematic review of library programs and allow for a redefinition of what the library can realistically hope to do well enough to be worth doing. The process could lead to the tough decisions that must be made eventually and that can be made with the least impact on programs identified as essential.

The discussion related to Worksheet II illustrated the difficulty and complexity of the budget reduction process. There was general agreement that the library administration would require a substantial amount of information from library staff, university administrators and library users regarding which library programs were essential, which were relatively unimportant, which might be reduced with minimal impact and which program reductions would contribute significantly to cost savings.

However, in the discussion of where cuts could actually be made, the difficulty of the process became apparent. Everything that libraries do is important to someone: to library staff because it can mean their jobs; to faculty because they want their specific areas of research well supported by the collection; to students because they need library materials and services to achieve good grades. Because the academic library operates within an environment which is typically highly politicized, it has limited maneuverability. Frequently, the library must respond to forces beyond its control: new academic programs are often begun by university administrations with little or no understanding of the library's costs in developing supporting collections; frequently there is inadequate library involvement in the university planning process; and national developments such as changes in copyright legislation may limit the possibilities of resource sharing.

6.0 CONCLUSION

The following fundamental concerns were identified by the workshop participants as requiring attention:

- *Need to understand the environment.* An academic library manager needs to know university trends as well as national trends in resource sharing and library related legislation.
- *Need to understand the local political situation.* One must know where power centers exist, and develop a strategy to deal with and influence these centers.
- *Need to develop tools and techniques for gaining a fuller understanding of real user needs and the options for fulfilling those needs.*
- *Need to move toward more effective modes of cooperation with other institutions.*
- *Need to make tough decisions.* Academic libraries no longer have the luxury of continuing existing programs while adding new programs and services.

Continuing academic pressures call for a rethinking of the fundamental role of the nation's research libraries. This national need, that goes beyond local decision capabilities, requires a national commitment to, and strategy for, the maintenance of distinctive research collections and for effective sharing of resources. Within this context workshop participants expressed optimism that the service role of individual academic libraries can be maintained and perhaps enhanced.

CHAPTER 10

by FRANK LAND

Economic Analysis of Information Systems

1.0 INTRODUCTION

The topic of economic analysis of information systems is sufficiently broad to cover a number of distinct but interdependent topics. A useful way to classify these is: the problem of estimation; the investment decision problem; the problem of measuring achievement; the cost allocation problem; and the project control program.

The problem of estimation covers forecasting the costs and benefits of a proposed system over its expected lifetime.

The investment decision problem occurs when one attempts to compare the return on the proposed system with the return from using the resources needed for some other project. In general the method chosen by an organization for making investment decisions should also be applied to information systems projects. Thus, if an organization uses a discounted cash flow method for allocating resources, it should use it for making decisions on computer projects as well. At the same time the organization should be clear that cash flow projections stemming from some kinds of proposals involve much more uncertainty than those stemming from more conventional projects.

The problem of measuring achievement is faced when one attempts to monitor the system in operation, and compare estimated costs and benefits with actual costs incurred and benefits received.

Measuring achievement requires that, for each expected outcome of the system, there is an appropriate performance measure. If a system is designed to improve the accuracy of certain information, then a measure of accuracy must be defined. This might be expressed in one or more of many ways. However, as a general rule, the system should be designed to be self-monitoring and to output its own performance statistics.

Even if performance statistics are available, there remains the formidable problem of relating changes in performance to changes in the system. To assess the extent to which performance changes are due to other factors which affect the system coincidentally, one may ultimately have to rely on arbitrary assumptions. Cause and effect relationships are not easy to establish.

The cost allocation problem involves charging those who are intended to benefit from the system with the cost of developing and operating the system. Alternatively, one can use a pricing system to allocate costs.

Cost allocation involves decisions on the apportionment of costs between joint beneficiaries, and on allocating fixed costs to users who have no control over the costs. Since most information systems have high fixed costs and benefits are shared, most cost allocation schemes involve arbitrary decisions on splitting the costs.

The project control problem is controlling the development process with respect to its use of time and resources.

The main emphasis of the workshop was on the first topic – estimating the effects of the proposed system on the organization.

2.0 THE LIFE-TIME OF THE PROJECT

Any new system planned is expected to have a lifetime which enables it to make a contribution to the organization commensurate with the investment incurred in its implementation. At the same time no organization can survive if its information system is subject to a rapid rate of systems changes. Thus the planned lifetime of a system is not likely to be less than five years even though, during that lifetime, some changes in system must be accommodated.

Since it may take from six months to ten years to implement a new information system, the total time from the initiation of the project – when some of the crucial design decisions are taken – to the end of the system's useful life will span many years. A system which takes three years to implement and which is expected to be operated for a further five years without major changes, has a total planning horizon of eight years.

The planning horizon has to be related to the forecasting horizon, the time over which it is possible to make reasonably reliable forecasts of those factors which affect the functioning of the information system. For many organizations the forecasting horizon is quite limited. Requirements for an information system are subject to changes within the organization including changes in personnel, changes in the environment including changes in laws and regulations, and changes in technology which the technology in use obsolete.

As a general rule the planning horizon should not be larger than the forecasting horizon. If the planned changes have a planning horizon which goes beyond the forecasting horizon, it may be necessary to:

- *Make available more resources* so as to implement the new system sooner. However, this may increase the cost of implementation too much.

- *Partition the system into smaller modules,* and implement one module at a time. However, this may make the payoff from the system smaller.

- *Reduce the level of ambition* by planning smaller, simpler changes. This again may reduce the payoff from the new system.

3.0 MEASURING BENEFIT

The purpose of making changes in an information system is to provide benefits for the organization. To assess the potential benefits of changes, it is necessary to establish specific targets or goals to which the changes are oriented. Further, one must establish methods of measurement which enable the systems designers to align the new systems with the targets.

Changes in the operation of an information system within organizations may be contemplated for many reasons. A new technology may become available, there may be a bottleneck in the existing system, or there may be a shortage of some resource like skilled workers. However, any change will have significant effects on many aspects of the organization's activity. Some of these effects may be generally beneficial, but others may be deleterious. Some effects may be beneficial to one group within the organization, but have adverse effects on another group. Finally, some effects of change may contribute toward the goals of the organization while others may make it more difficult to achieve goals.

The first step, then, is to identify and classify the possible beneficiaries from a change to the information system. It may be useful to identify five classes of beneficiaries to whom a change in system presents an opportunity or a threat.

3.1 Holders of Financial Interest

In the case of universities, those with a financial interest in the enterprise will include: students whose tuition rates are in part dependent on the cost of administration; the public, to the extent that their taxes support the university; and the faculty since reduced administrative costs would release more resources for academic functions. All these seek a financial benefit. And historically, they, or their representatives, have dominated the evaluation process, often because their goals are regarded formally as the only acceptable goals of the organization.

In addition to financial opportunities and benefits the decision makers may also be faced with financial constraints in the form of acceptable rates of return on capital or limits on capital expenditure.

3.2 The Employees

It has become fashionable in recent years to pay greater attention to the aspirations and job satisfaction of the employees of an organization. Experiments in industrial organizations, such as "T groups", have been set up in various countries. In part, the movement is humanitarian in origin, but its main driving force is the realization that designing jobs to suit the aspiration of the worker is an important step towards higher and more consistent performance.

Any information system comprises procedures, some of which may be carried out by computers, and some of which are carried out by people. Since any change in system will have an effect on the way procedures are carried out, a change in system can be used to enhance the job satisfaction of the people carrying out the procedures. However, a change in system may also reduce the quality of a job and the satisfaction it provides.

If we follow the humanitarian school we may wish to avoid changes which diminish job satisfaction. But it may be difficult to persuade the financial interests to give any weight to such considerations. However, strong evidence is available that the short life, or relative failure, of many complex computer projects is often due to a failure of the people within the system to work the system properly. Although the failure is often put down to inadequate training, it is probable that, in most cases, those working within the system have found it unacceptable because of a reduction in job satisfaction.

3.3 The Organization and Its Managers

The structure of an organization and its style of management is the product of the organization's history, and of the technology available to it. Yet, in most organizations, structural change is always taking place. Functional boundaries change, systems of control change, and the style of management changes. Although these changes are expected to improve the performance of the organization, they may be regarded as goals.

Since introduction of changes in the information system link with changes in structure and control, the use of computers can have profound effects on the organization and its managers. Any change can be regarded as an opportunity to contribute to the goals of organizational change, or these goals may be regarded as contraints on the nature of the changes which may be permitted. In a university setting methods of organization are currently very much under review. Some universities, for example, are considering departmental responsibility accounting and budgeting.

3.4 The Customers and External Relations

For some organizations, the provision of the "best" service for its customers is the major goal. Even for profit-oriented enterprises, service to customers may be an important area of company policy. Changes in information systems may make significant contributions to customer service in terms of improved reliability and accuracy, in terms of reduction in service delays and many others. On the other hand, the changes can affect customer services adversely.

Other groups with whom the organization has relations, such as suppliers, trade unions, and government departments, may also be affected by changes in systems, and must therefore be considered in any process of evaluating systems changes.

3.5 The Community At Large

The general image of computers as seen through the eyes of newspapers, television, radio, and literature is, in the western world at least, tinged with mysticism ("electronic brain") and regarded as a threat ("big brother") rather than as a tool for the good of the community. Similarly, the image created by the use of computers within an organization can affect its external image. At the same time the use of computer systems and related archives of information about members of the community, can have direct effects on the public, through breaches of confidentiality and threats to the privacy rights of the citizen.

The preservation of the organization's public image, and the protection of the citizen's privacy rights may therefore be considered a part of its goal system. Sometimes these goals are externally enforced with sanctions as in the Swedish data bank laws.

In developing countries in particular, it may be possible that the use of computers for information systems may play an important part in developing the social infrastructure. In these countries, the role of organizations such as universities is far broader than merely producing highly educated citizens. Computers in organizations may, if used properly, help indirectly to raise levels of understanding of technology, of systems thinking, of discipline in systems. Certainly the existing social infrastructure places constraints on the development of computer based information systems.

The goals of the organization can be considered in terms of the goals of each set of beneficiaries. To provide measurable targets for an information system the general goals for each class of beneficiary can be broken down into specific targets which have measurable properties. For example the organizational goal of providing a system of departmental budgets can be broken down into a set of specific goals related to:

- *timeliness,* for example, the frequency of reporting budget variances.
- *reliability,* for example that 95% of reports are not to be more than two days late.
- *accuracy,* for example that the undetected error rate should not rise above 0.5%.

In a similar way financial targets can be broken down into specific targets such as cost reductions achieved by eliminating certain manual tasks, or cost avoidance by putting on the computer certain jobs which would be prohibitively expensive if carried out by other means.

The method of measuring benefit, then, is not in terms of a common unit such as money, but in terms of a unit appropriate to each kind of goal. No attempt is made, for example, to measure the money value to the organization of improving the fit between the skills an employee brings to his job, and the extent to which he can employ that skill in the performance of his job.

Eventually it is necessary to arrive at some kind of value for each goal. One way to attempt this is to give each goal a weight in relation to all other goals. For example, it may be possible for senior management to determine how much value they assign to goals related to job satisfaction as against goals related to customer satisfaction, or against goals related to an improvement in the control they can exercise over the activities of departments. In practice, different people and different groups will accord different values (or weights) to the goals. The head of a faculty might tend to give a higher weight to targets associated with academic performance, while the financial administrator might give higher weights to targets related to savings in administrative costs. In the real world subjective valuations of this kind are often hidden, although their presence can lead to unexplained conflicts within the organization, and will certainly affect the behaviour and performance of individuals.

An important step in the evaluation process is to ask different groups to make their assessment of the relative importance of the different goals. If there is a wide divergence between goal values it may be necessary to take steps to resolve a potential conflict. Sometimes the mere fact of bringing the different views into the open is enough to help resolve the conflict. At other times, where a proposed change provides a benefit for one group but a perceived loss to another group, it may be necessary to provide the losing group with some compensation in terms which they find acceptable.

The evaluation process: –

- Identifies those who might benefit (or lose) from a new or changed system
- Explores the opportunities provided by the new system in terms of specific measurable targets
- Provides a set of weights for each target, where the weights are given by the various individuals or groups who will be involved in the change.

The next step in the process is to assess how different designs of systems might contribute to the achievement of the targets. Each possible system alternative is ranked according to its contribution to each target. In practice it is best to reduce the number of alternative designs to four or five. Then, taking the existing system as the reference system on a scale of –5 to +5, with the reference system ϕ, one can rank the alternatives. Some system designs will contribute a great deal to the achievement of some targets, but do badly with respect to other targets. However, the targets are not of equal importance. By multiplying the ranking of each design by the weight attached to each target, it is possible to find the design which, over all the targets, can be agreed to contribute the greatest value to the organization.

The final step is to subject the outcome to a sensitivity analysis. In this analysis one can test, for example, whether a small change in the relative weights assigned to targets would affect the choice of designs, or whether changes in the assumptions about the relative performance of the different designs would affect the result. Where small changes make critical differences it is best to reexamine the weights and measures used.

4.0 EFFICIENT AND EFFECTIVE SYSTEMS

An information system is of value to an organization if its output is used to further the goals of the organization. However, the important goals are not fulfilled directly by the output of the information system, but depend on the way that output is used by the planners and decision takers. Because it is difficult to prove that the output of the system will be put to good use, there has been a tendency to restrict measures of benefit only to those elements which are directly observable and which will be reflected in cost reductions or cost avoidance. Many systems have therefore had the limited design objective of making existing processes more efficient by reducing their costs. It is hoped that the evaluation procedure described above, which involves the active participation in goal setting and goal evaluation by the users themselves, will facilitate the design of systems which are effective as well as efficient.

5.0 THE VALUE OF INFORMATION

Information has value if it is used to further the goals of the organization. To impute a value to information, one method relies on the subjective estimate of the user of the effect the improved information will have. Having obtained the subjective estimate of value, one can use Bayesian statistics to impute a quantitative value to improved information.

Suppose that a sales manager estimates that sales can be increased by means of an improved sales analysis. He assesses the probabilities of increased sales as follows:

- 1% increase 80% probability
- 3% increase 15% probability
- 5% increase 5% probability

The expected return on the investment in the information system is the expected additional profit generated by the extra sales. The extra profits for each possible level of sales increase might be:

- extra profit \$ 750,000 yields expected return of \$ 600,000
- extra profit \$2,250,000 yields expected return of \$ 337,500

- extra profit $3,750,000 yields expected return of $ 187,000

$1,125,000

The primary weakness of the method is that it tends to focus attention on one benefit variable only. In the example, the variable is extra profit from sales which is clearly a very important variable. However, limitation to one variable is a drawback. More importantly studies have shown that certain types of probability estimates occur more frequently than others. For example a probability of 80% will be quoted much more frequently than a probability of 75%, and it is quite rare to get estimates which are not rounded to the nearest 5 or 10%. However, small changes in probability estimates can have a large effect on the value of the outcome. In the example above if the probabilities were changed only slightly,

- 1% increase 75% probability
- 3% increase 18% probability
- 5% increase 7% probability

the outcome in terms of expected return would be $1,230,000 which is an increase over the previous estimate of 9.3%.

6.0 COST ESTIMATION

Cost estimation is somewhat easier than benefit assessment. However the record of estimating either resource use or time needed for the development of information systems is very poor. There are a number of reasons for this.

6.1 Decisions Without Sufficient Analysis

Crucial decisions may be taken before the full complexity of the system to be developed has been fully analyzed. A way of overcoming this difficulty is to adopt a policy of "creeping commitment". After the first feasibility study, a limited commitment is made for a further more detailed study. If this suggests that the project is still worth implementing, a further commitment is made for some actual designs. Final decisions about the project are avoided until a sufficient amount is known about the proposed system to reduce the risk of grossly bad estimates.

6.2 Lack of Performance Standards

Performance standards for systems design and construction are not generally available. New methods of organizing the design and implementation team involving top-down design methods, and techniques of modular design and structured programming are making it more possible to create accurate, reliable performance standards.

6.3 Underestimate of User Involvement

Estimates of the time spent by user personnel in the design and implementation stages of a project are often not considered in the project costings. Further, the disruption caused by the implementation process in the user departments while they are learning how to use the new system is not normally considered a cost of system development. However, all new information systems represent innovations, at least in the context of a particular user department. Hence information systems development and implementation should be treated as an experimental activity and costed accordingly.

6.4 Unforseen System Requirements

Not all aspects of a system's requirements are recognized at the time the estimates are drawn up. To recognize as great a proportion of system requirements as possible, it may be helpful to isolate and plan for three modes of system operation.

- *The normal mode,* with expected volumes and transaction types.
- *The abnormal or breakdown mode,* when some component of the system fails or has to operate in a degraded state (hardware failure, influenza epidemic), or volumes reach unexpected levels, or unexpected events occur.
- *The recovery mode,* where the system which had to be degraded in the breakdown mode is brought back to the normal mode.

Each mode needs to be designed and implemented. The fact that an event occurs only at rare intervals does not reduce the effort needed for design and implementation where the system is computer based.

6.5 Interruptions

The design and implementation process is interrupted by the need to cope with changing requirements. This problem, together with the others outlined above, have contributed to the poor record of estimating system resource use and time requirements.

7.0 STRUCTURE OF THE FEASIBILITY STUDY

A feasibility study should consist of a number of defined phases, each of which may have to be repeated in the light of the outcome of the next phase. The output of each phase represents the input to subsequent phases. The phases are:

1) Define problem boundary and planning and forecasting horizons.
2) Choose goal setting and evaluation personnel.
3) Analyse significant internal and external trends over the planning horizon.
4) Identify the opportunities and constraints within the systems boundary.
5) Specify alternative systems designs.
6) Estimate contribution to goals from each alternative design as of now.
7) Rework the contributions on the basis of future trends.
8) Rank options in the context of the weighted goals.
9) Check sensitivities and validity of outcome. Return to earlier stages if necessary.

In the feasibility study, all of the methods of estimating costs and benefits of various aspects of system design ought to be employed.

APPENDIX A

Conference Attendance
Spring 1976 EDUCOM Conference

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APPENDIX B

The Task Group on Principles Standards And Guidelines for Management Control Of Automatic Data Processing Activities And Systems

A task group of very highly qualified ADP management professionals was commissioned in September of 1973 to study the problems of management control of ADP activities and systems and to make recommendations to the GAO of suitable guidance which could be given to the appropriate managers and auditors in the Federal government. This task group settled on a building block (phased) approach to the subject of management control guidance as the best means of achieving meaningful results and successful implementation. Their initial effort addressed the cost accounting and cost control processes as a critical central element of management control. Specifically it addressed itself to three of the four areas of concern:

- systems design and development activities,
- data processing and communications operations activities, and
- cost assignment to end user units of the organization,

while leaving the fourth area of concern to subsequent studies, i.e., total information handling and processing activities of an organization. The task group submitted its report of recommendations in September, 1975, to the GAO.* It has been cleared for release to interested individuals upon request and we will be very interested to receive their comments on these concepts and recommendations of the task group.

Data processing systems are a unique and very pervasive resource to the Federal government. There are a myriad of applications and application situations which are to be comprehended within the scope of government-wide guidance on automatic data processing activities and systems. The task group has done an outstanding job of anticipating the potential problems of implementation of its recommendations over this vast range of applications and situations.

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*Entitled "Management Guidelines for Cost Accounting and Cost Control for Automatic Data Processing Activities and Systems". A report of recommendations to the Director, Financial and General Management Studies Division, U.S. GAO, September 17, 1975. It is not a GAO report.

It should be recognized that ADP activities are but a part of the totality of the Federal government — a very pervasive part to be sure — but still only a part of Federal activities. Thus, in developing its guidance the task group, and now GAO, must be very cognizant of the accounting, budgeting, and financial management systems that are in existence in the Federal government and assure that such guidance is implementable and complimentary. The GAO's *Accounting Principles and Standards for Federal Agencies* (Revised 1972) is the most authoritative guidance to the Federal agencies on accounting. Thus, it is the most appropriate baseline for any guidance or recommendations.

MANAGEMENT CONTROL CONCEPTS

The task group set forth four very important concepts basic to the issues of cost accounting and cost control:

Formal Planning: Maintaining current formal plans and budgets for ADP activities and systems, which are related to organizational objectives, and which view the future to the point where objectives and investment benefits could be realized.

This concept anticipates a "family of plans" closely related and integrated by consistent assumptions and correlated anticipated actions and results. Emphasis is given to:

- financial and operational expressions of these plans and budgets,
- stated measurable accomplishments anticipated,
- long range period plans and financial projections, supplemented by annual and lesser period plans and budgets,
- project and system life cycle plans and budgets,
- period and accomplishment-related reviews, and
- a process for maintaining the currency of plans and budgets.

Life Cycle View: Planning, controlling, and accounting for ADP system with a view to the expected overall life cycle composed of the four major phases: design, development, operations, and evolution. Recognizing that the expected life cycle of critical components (such as expensive hardware and software) influences an expected overall ADP system life cycle.

This concept anticipates carefully designed life cycle financial plans, reviewed and revised at meaningful time points, as essential to both long-range planning and operating management control.

Resource Utilization Measurement: Measuring, relating and reporting resource availabilities and uses in terms of objectives served, results achieved, and management responsibilities for ADP systems, projects, and functions. Laying specific stress on expression of such resource utilization measurement in both financial and operational terms meaningful to ADP management and to top management.

Quantitative measurement of resource utilization (i.e., personnel, equipment, material, etc.) is needed for effective management control. The task group states that all levels of management control are dependent upon timely, organized resource utilization information and unit cost information, with actual-to-planned comparisons and variance identification.

Management Reporting: Reporting is required in financial terms meaningful to management and to end users of ADP services of the benefits, costs, and accomplishments, relatable to their responsibilities, decisions, and actions.

The payoff of formal planning, life cycle view, and resource utilization in controlling ADP activities and systems comes largely through an effective management reporting system. The task group views the end user of ADP services as principally responsible for their effective and economical usage. Their approach to expressing this responsibility is through requiring that the full cost of ADP products and services be transferred, assigned, to the end user units of the organization. Further, the task group recommends that the resource utilization measures and unit cost data be reported to end user management and to top management in meaningful terms to their analysis and control responsibilities.

COST ASSIGNMENT TO USER UNITS OF AN ORGANIZATION*

Implementing a cost assignment procedure aids management in several ways. First, when the user knows the cost of his service, he is in a position to perform a cost/benefit analysis and can determine whether the value received from a service is worth its cost. As a result, user become more cost conscious and sometimes reduce their demand for services. Second, the ADP manager is aware of the cost of operations of each user, and is in a position to concentrate of those high cost and demand areas warranting attention. And finally, top management can benefit from the cost information in fulfilling its responsibility for making sound ADP investment decisions.**

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*The report refers to organizational unit(s) receiving the products and services from the ADP activities as the "end user units." Because of the large number of "users" who receive reports and other types of ADP products and services, we believe cost control can be enhanced by the designation of an official within an end user unit as a focal point of responsibility for the cost of ADP products and services. This person is referred to as an "end user."

The principal elements of defining responsibilities through cost assignments are to reflect accurately, to the extent possible:

- The authority of the manager for cost incurrence;
- The accountable responsibility of the manager;
- The degree of cost controllability exercised by the manager; and
- The relationship of the cost to his decisions.

The proper assignment of cost depends on a number of factors, sometimes referred to as the attributes of cost assignment. The attributes considered in this report, although not explicitly mentioned in our guidelines, are a prerequisite to any assignment of costs. Briefly stated, they are that:

- The value of the information provided through cost assignment should be greater than the cost of administering the procedure;
- Cost assignment should result in equitable charges to all users;
- Cost assignment should result in charges which will be consistent for like work;
- The cost information provided be relevant to the decisions, actions, and responsibilities of management; and
- Cost assignment should satisfy legal and other official administrative restrictions and requirements.

UNITS OF MEASURE COMMONLY USED IN MULTIPROGRAMMING ENVIRONMENT

Resource	**Unit of Measure**
Central Processor Unit	CPU Hours, Minutes, or Seconds.
Internal/External Memory	Kilobyte hour, Number of word blocks used, Region size in kilobyte units, Elapsed time.

**A senior management official may be designated as having agency-wide responsibility for reviewing and evaluating the cost-effectiveness of all ADP products and services.

Input/Output	Number of accesses, Number of tape or disk drives used, Sum of unit record transfers (sometimes in a block, e.g., per 1000 cards read), Elapsed time (e.g., disk channel time in seconds).

Summary or general information is often provided when an installation has few users. More complex, specific, and detailed information is generally provided when there are many users. Cost assignments are generally based on the level of input resources used in generating ADP products and services. However, if outputs are relatively standardized, one should consider the possibility of assigning costs on the user units of output (e.g., invoices issued, transactions processed, or accounts updated). The standard cost per unit of output could, of course, be calculated on the expected or average level of input resources used to generate the output.

Cost assignment should be related to the consumption of resources actually used in providing the ADP products and services. However, in some cases, costs should be assigned on the basis of resources that have been committed whether used or not. For example, a user, in a multiprogramming environment might request the allocation of three tape drives for his program. If these tape drives cannot be used by any other program until the user's program is completed, the user could be charged for three tape drives whether he actually used all three or not. Similarly, resources can be committed by a contractual agreement, such as an agreement to have the computer system available for dedicated use during certain hours of the day. The user could be charged whether it is used or not.

MANAGEMENT REPORTING

The cost assignment procedures should being to management the information needed in the form required for management decisions. The cost assignment procedures may result in a dollar-billing process based on the aggregated information. It is also possible to provide resource utilization measures in terms of equipment usage and personnel time. These may be part of the cost assignment report, separate memo billings, or contained in other management reports.

GUIDELINES

1. Cost assignment should generally reflect the full cost of resources used or committed.

Full cost generally includes directly relatable costs such as wages and related personnel costs, supplies, interagency and intraagency services, depreciation or amortization of hardware, long-lived software, and facilities assets.

II. In certain instances it may be desirable to employ rate differentials for those considerations which promote more efficient or economical use of the resources.

Users wanting priority turnaround, for example, should pay a premium to encourage users not to ask for fast turnaround if the added value of such service is less than the priority premium. Similarly, peak periods (e.g., during the day and at month-end) should carry higher rates to help smooth the load. In composing a budget, a balancing of total premiums against total discounts should be planned to achieve full cost assignment.

III. A priority system may be employed in conjunction with cost assignment if management control over ADP will be improved.

Generally, a priority system should be used to control systems design and development as well as data processing operations. Establishing priorities should generally be the responsibility of a management committee where both ADP and user management are represented.

IV. Cost should be assigned on the basis of predetermined rates.

In special circumstances, it may be appropriate to assign actual costs, such as in the transfer of contract service costs or travel expenses (often termed "unique costs").

V. Rates, once established, should be effective for as long as possible.

They should be reviewed at least annually and updated as necessary. Certain conditions, for example, a significant departure from planned usage may warrant rate review and possible adjustment on a more frequent basis.

VI. Predetermined rates should generally be set using either projected levels of effort and estimated costs and/or last year's actual costs and usage.

Only in certain cases may it be more advantageous to use an historical averaging of costs and usage to derive the rate. To encourage demand in new or experimental installations, predetermined rates could be set using projected levels of effort. The fact that variances may occur must be foreseen and their allocation predetermined. For example, a startup account may be designed to pick up the variance.

VII. The unit of measure chosen as a basis for assigning costs should be closely related to the resource being measured.

VIII. Cost should be assigned by applying the predetermined rate to some unit of measure of the resources actually used or committed.

IX. Variances to predetermined rates should be analyzed by management. If a variance is caused by a user, it should be applied to that user.

A material variance not so attributable may be allocated in one of four ways:

- to general overhead,
- to all users,
- to the ADP organization, or
- as an adjustment to next year's rate.

X. The frequency with which users are notified of their ADP costs should coincide with an activity's accounting cycle which is usually a monthly cycle.

Individual users may be notified on a more frequent basis by memorandum billings – usually issued upon completion of a specific task or job and including resource usage information.

XI. To the greatest extent possible, costs should be assigned in a manner that will allow user analysis and control.

Users should be able to understand their ADP bill and interpret its content properly for their decisions, planning, and control. This means that where feasible costs should be stated in terms of the user's operations or transactions, through standard product costing methods.

XII. Regardless of the formal scheme for assigning costs, every user who makes decisions that materially affect ADP costs should be provided cost information that aids him in the more efficient use of ADP resources.

REMAINING PROGRAMS

The task group discerned several other problems which will require the attention of GAO and the other Federal agencies. Some of them are:

- How does one assign development costs associated with a large information system used jointly by many subunits of an organization?
- Should there be a standard approach to the capitalization and amortization of owned hardware and software or the lease equity in such assets?

- How should excess hardware capacity be treated in cost assignment?
- What type of a data base is needed to evaluate the relative merits of competing cost assignment methods and for providing guidance on the effectiveness of specific methods in specific sets of circumstances?